Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

JANUARY, 1958

TECHNOLOGY DEPT.

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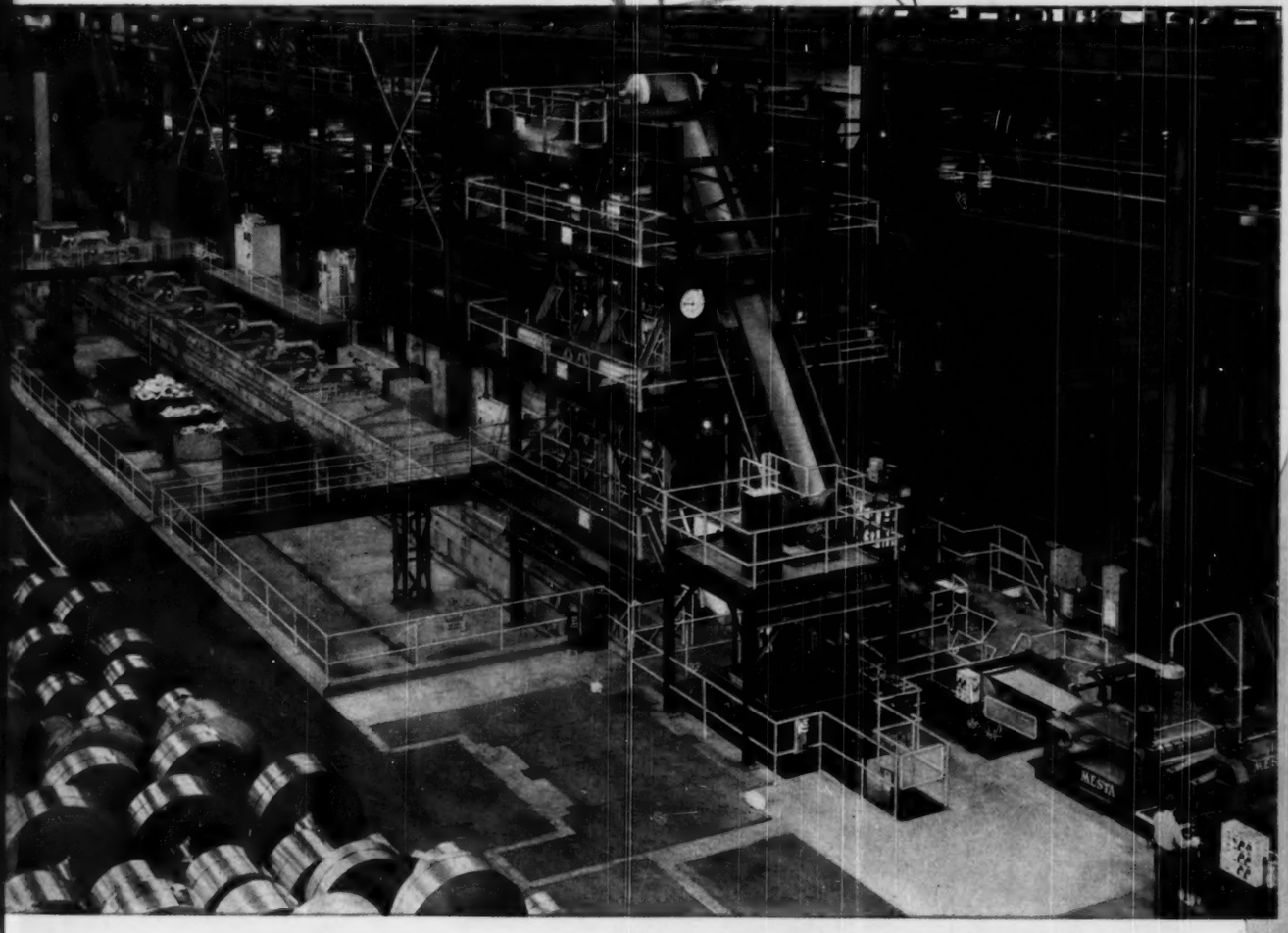
Continuous galvanizing lines

Designed and Built by MESTA



Mesta 48" Continuous Galvanizing Line

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

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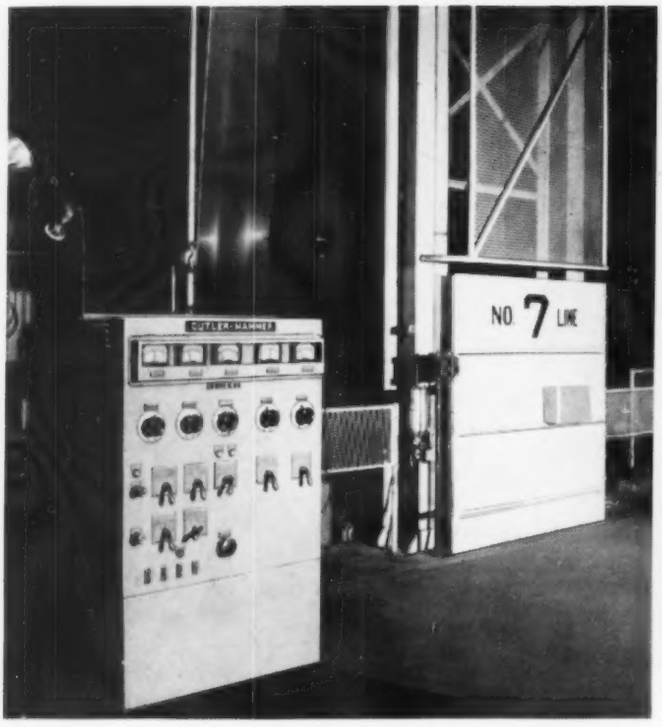
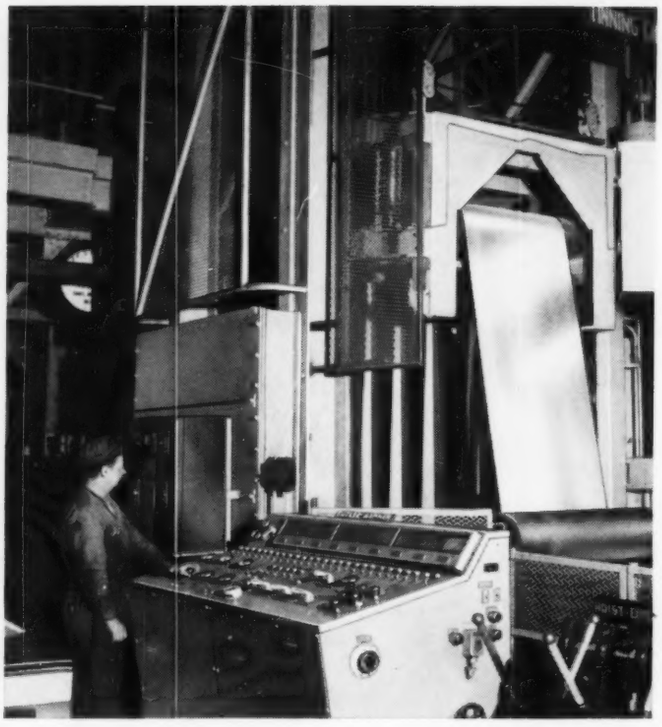


No. 7 Entry Station—Cutler-Hammer Control regulates the strip speed as the endless ribbon of steel is fed into the electrolytic tinning line. Maximum line speed is 1,000 feet per minute.

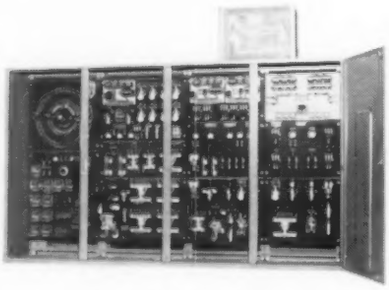


No. 7 Exit Station—From start to finish, the entire operation has been under Cutler-Hammer Control. Cutler-Hammer differential plating control automatically maintains the proper plate thickness for each side of the strip regardless of line speed.

Line after line...year after year it's Cutler-Hammer

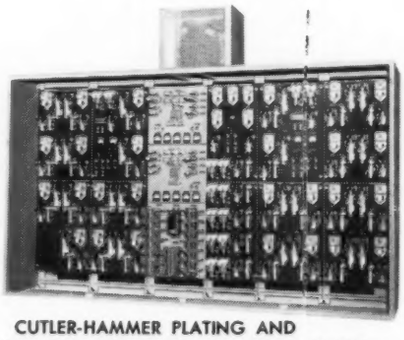
During the past five years, five electrolytic tinning lines have been installed at intervals in this well-known mill. A sixth line is now being installed. All six are completely equipped with Cutler-Hammer Control! The motor drives have Cutler-Hammer Control. The plating control is Cutler-Hammer . . . control with magnetic amplifier regulation to automatically maintain any preselected plating thickness regardless of line speed. And this is differential plating in which the thickness of plating on the top and bottom of the strip is controlled independently.

In mill after mill across the country, the performance of Cutler-Hammer control equipment year after year for job after job provides impressive proof of its dependability. This has been going on for more than 60 years. You, too, will find it pays to look to Cutler-Hammer for lasting satisfaction in the handling of all your mill control problems. CUTLER-HAMMER Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.



CUTLER-HAMMER LINE PROCESSING CONTROL SECTION

CUTLER-HAMMER
MOTOR CONTROL
C-H



CUTLER-HAMMER PLATING AND CLEANING GENERATOR CONTROL SECTION

LOOK TO CUTLER-HAMMER MILL EXPERIENCE . . . AS BROAD AS IT IS LONG

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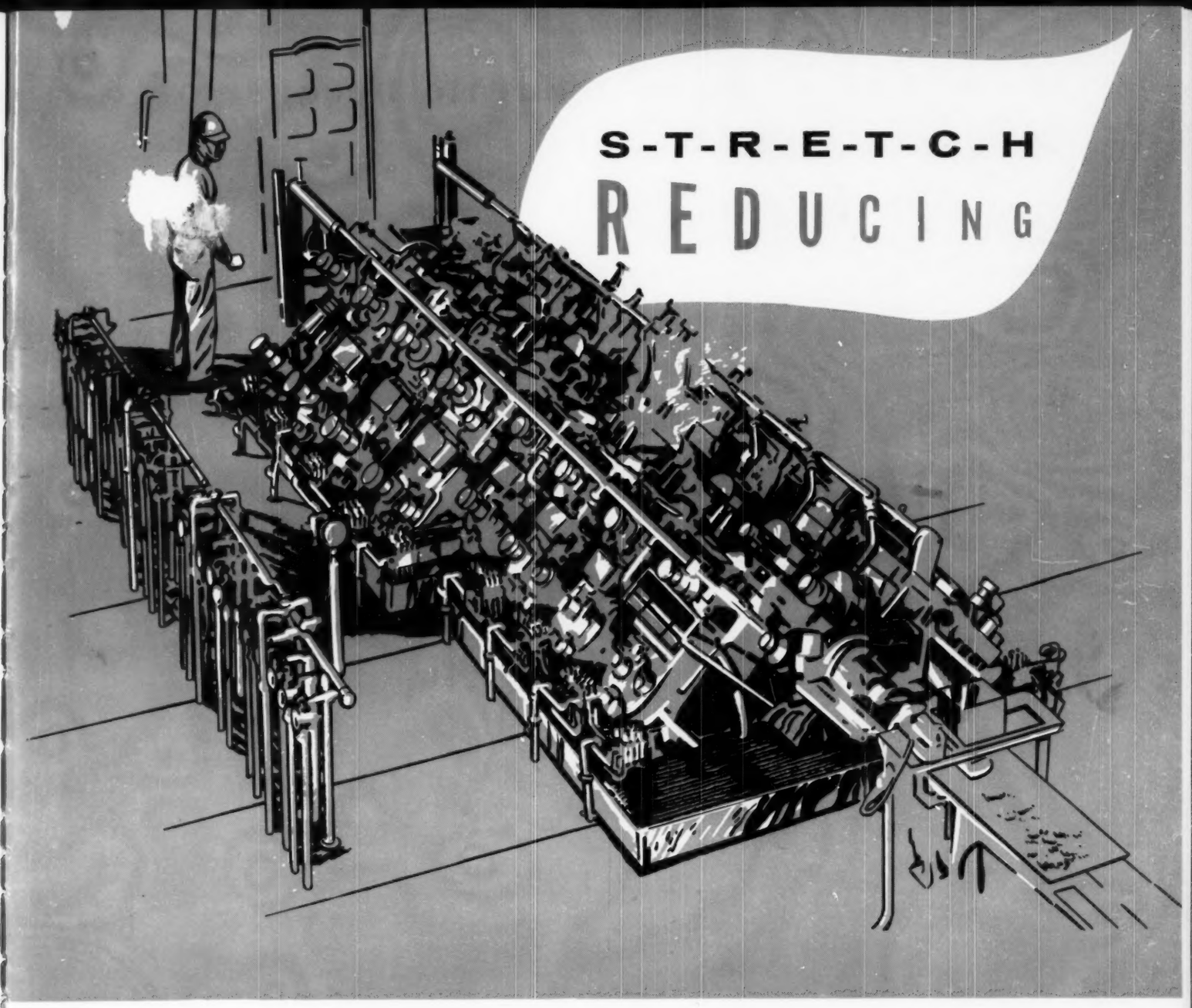

● Much of the news in Seamless concerns the Stretch Reducing principle. The first such mill was installed by National Tube Division of U. S. Steel Corporation. Aetna-Standard collaborated with National Tube in designing this mill and supplying the equipment. Since that time, much development work has been done on the equipment and the process.

Chief advantage of the Stretch Reducing method is the resulting increase in tonnage from existing Seamless Tube Hot Mill equipment for the production of A. P. I. steel tubing. Briefly, tubes of the larger O. D. (6″ to 7″) are produced through the existing Piercer, Plug Mill and Reelers, thereby obtaining a maximum number of tubes at an increased tonnage per operating hour.

Aetna-Standard has built and is building most of the Stretch Reducing mills. If your group needs facts on cost, design, yield and other information, Aetna's Seamless engineers can help you.

AETNA • STANDARD

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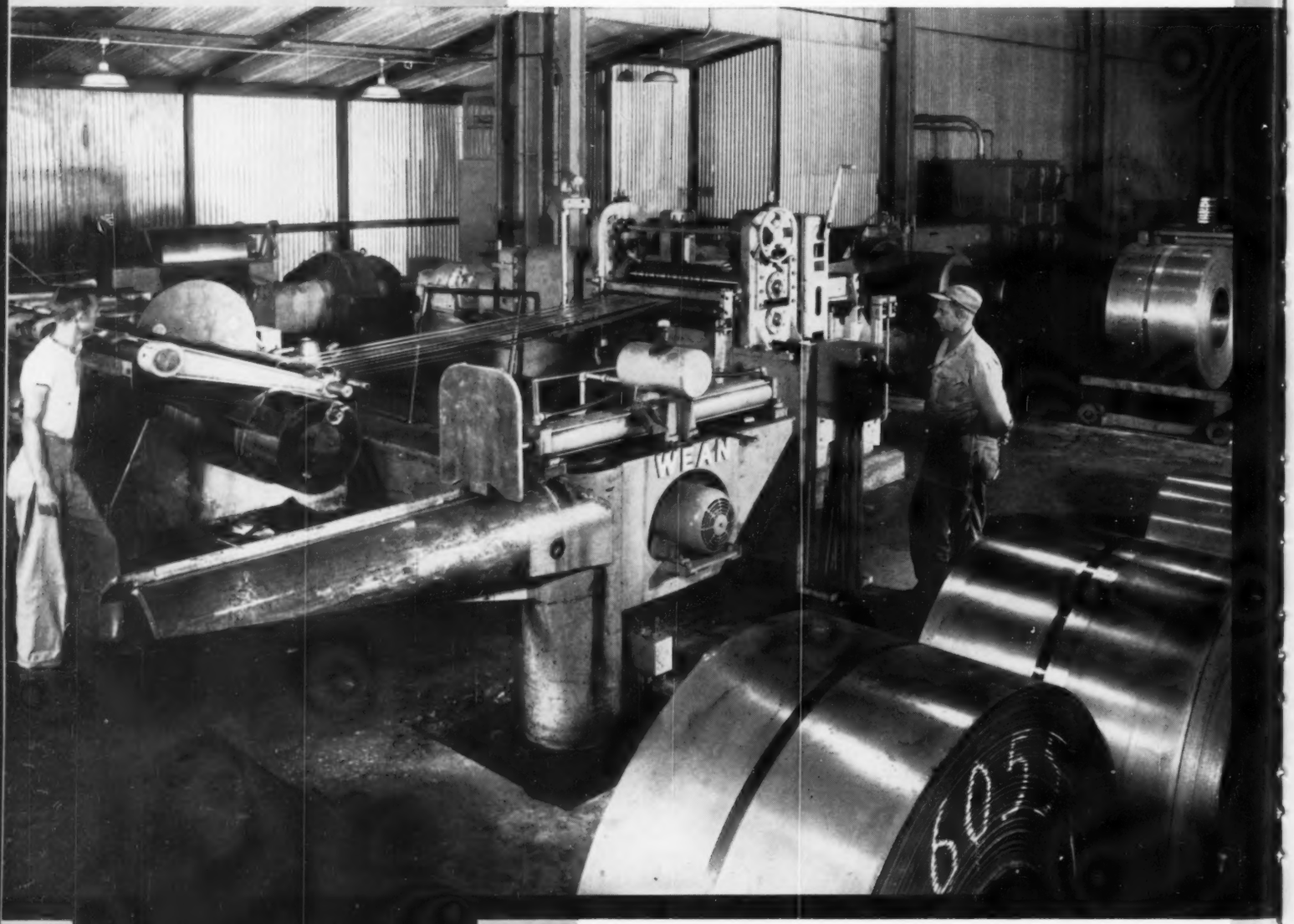

160

WEAN

- Wean high speed slitting lines are being used by more and more of the nation's steelmakers because they are engineered to perform the most accurate slitting job at cost reducing speeds. And, auxiliary coil handling equipment is designed to keep the steel moving — to get maximum production from the line at all times.

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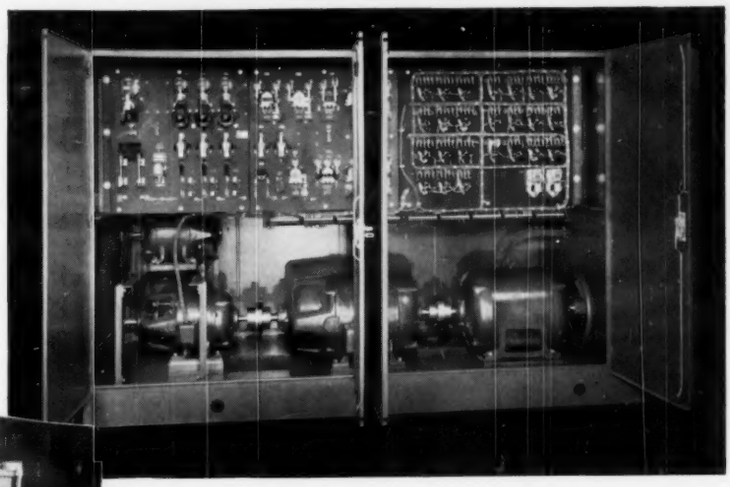

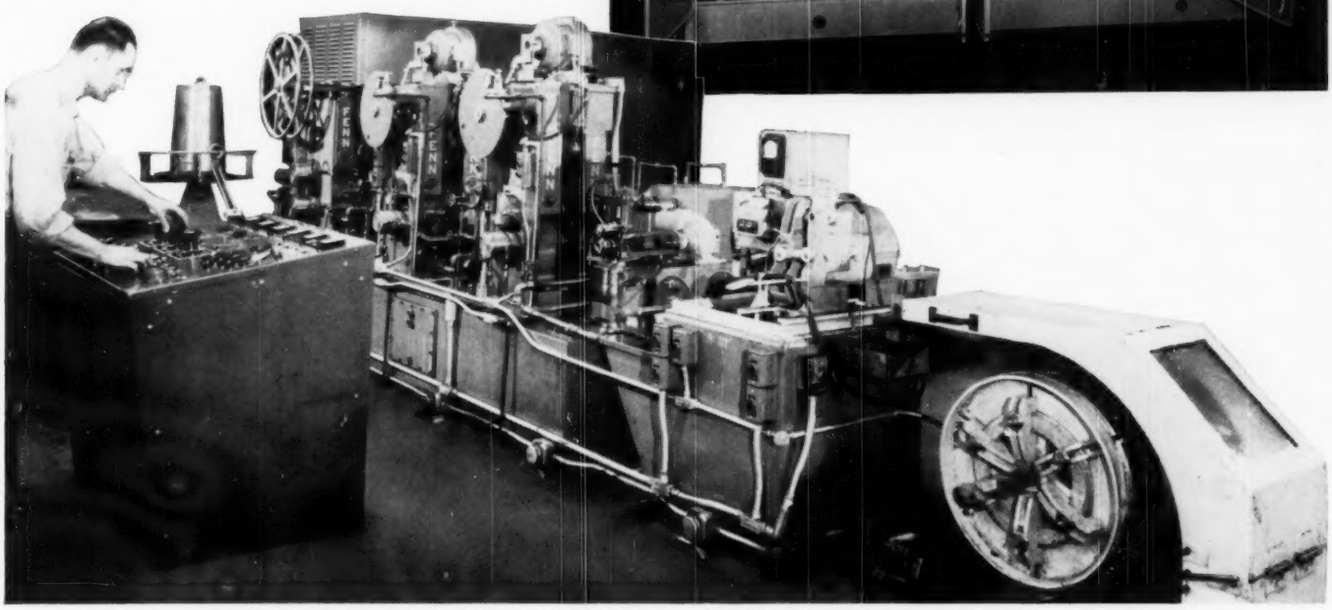

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"PSC" permits adjusting drive speed over a wide range by controlling motor armature voltage and/or field current. Modifications may be incorporated to adapt "PSC" to an almost limitless variety of applications where controlled-speed DC drives are advantageous.

Illustration shows a modern 3-stand tandem wire flattening mill with the individual stand drives synchronized electrically by Clark "PSC". Compared to similar machines in the same plant with mechanical synchronization, this mill is five times faster with more precise speed and tension control. Thus it holds closer tolerances and reduces breakage of light material.

***Write** for your copy of this booklet, telling you the Clark "PSC" story.*

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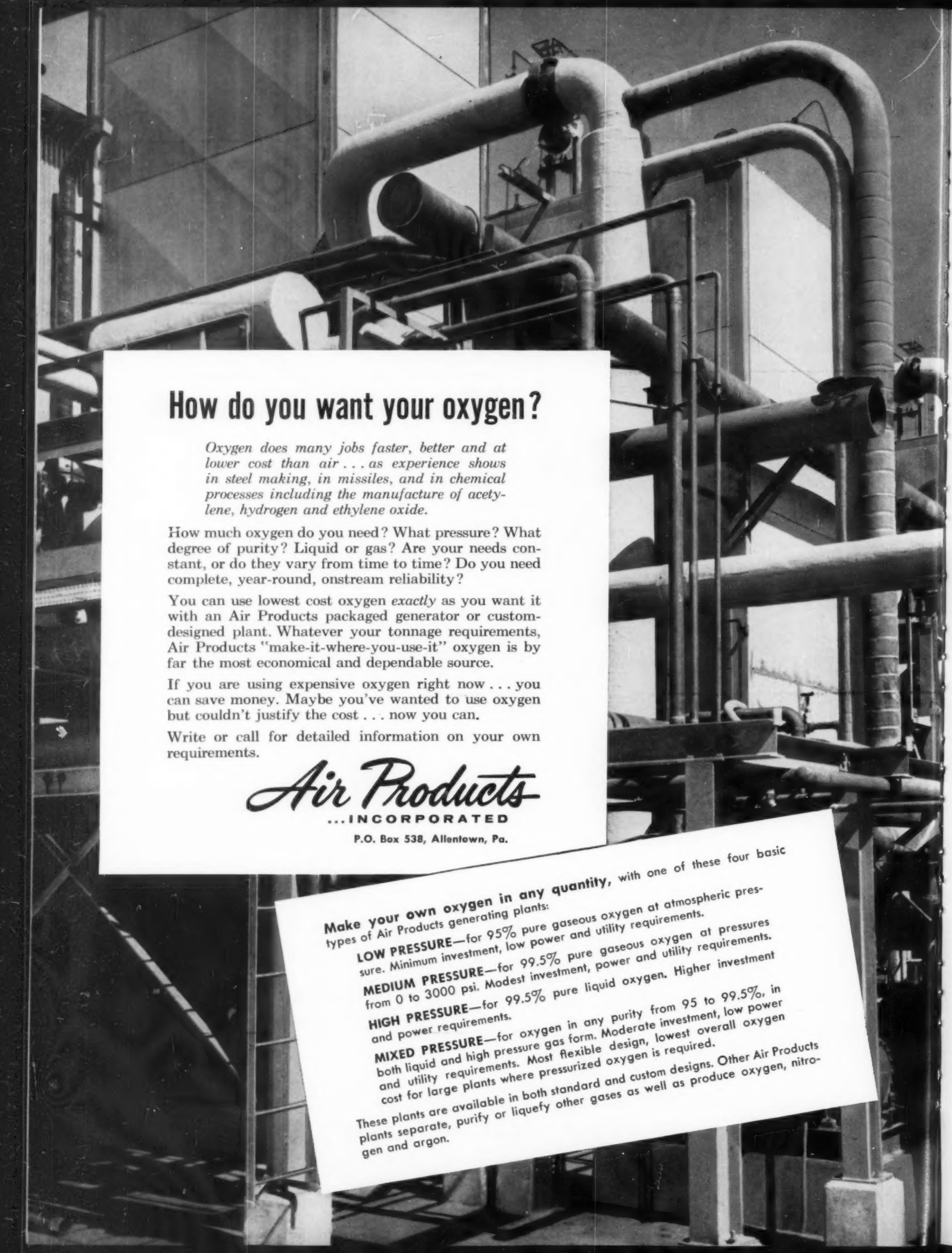

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You can use lowest cost oxygen *exactly* as you want it with an Air Products packaged generator or custom-designed plant. Whatever your tonnage requirements, Air Products "make-it-where-you-use-it" oxygen is by far the most economical and dependable source.

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These plants are available in both standard and custom designs. Other Air Products plants separate, purify or liquefy other gases as well as produce oxygen, nitrogen and argon.

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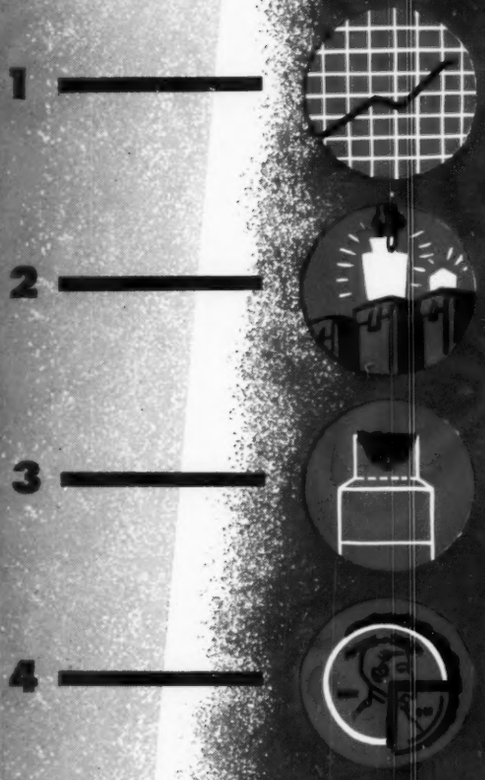

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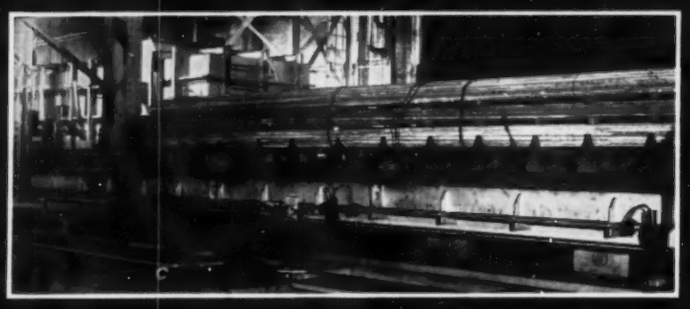


A thirty-foot straight bar furnace in operation at Youngstown Sheet and Tube's Briar Hill Plant.

Lee Wilson Merchant Bar Annealing System

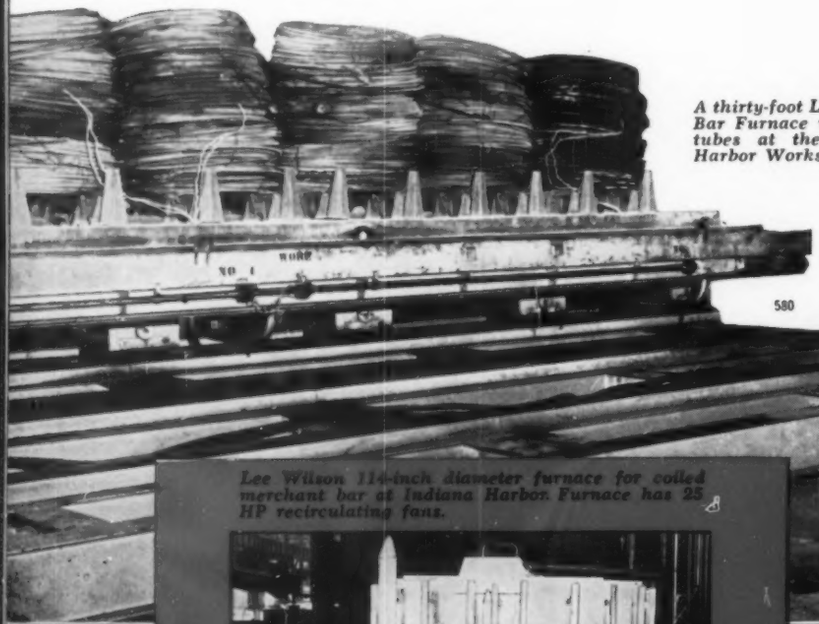
improves properties, finish...reduces costs

FOR annealing merchant bar in coils and long straight lengths Youngstown Sheet and Tube found Lee Wilson Radiant Tube Fired, Gas Tight Furnaces deliver the desired results. In both their Youngstown and Indiana Harbor works Sheet and Tube reports the Lee Wilson Furnaces process anneal, spheroidize, and lamellar anneal to uniform physical properties without decarburization.

For charges of either hot rolled and pickled bars or cold drawn material, treatments can be made to combine carbon restoration in the annealing process. Complete control of atmospheres is assured with oil seals between furnace and bases, and uniform contact with the metal with the process atmosphere is developed by the use of internal recirculating fans mounted in the furnace roof.

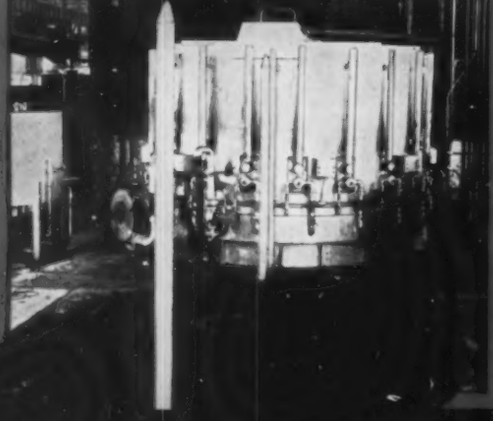
If annealing merchant bar, wire, rod, strip, or sheet coil—steel, aluminum or brass—is part of your business, Lee Wilson has the furnace to give you better results at reduced costs.

. . . at two Youngstown Sheet and Tube mills



A thirty-foot Lee Wilson Bar Furnace with base tubes at the Indiana Harbor Works.

Lee Wilson 114-inch diameter furnace for coiled merchant bar at Indiana Harbor Furnace has 25 HP recirculating fans.



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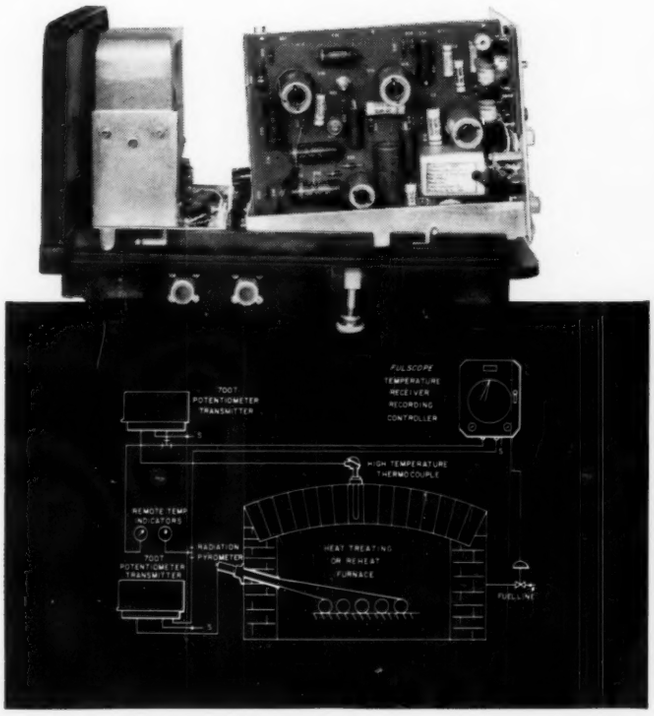
RUGGED . . . RELIABLE . . ACCURATE . AUTOMATIC

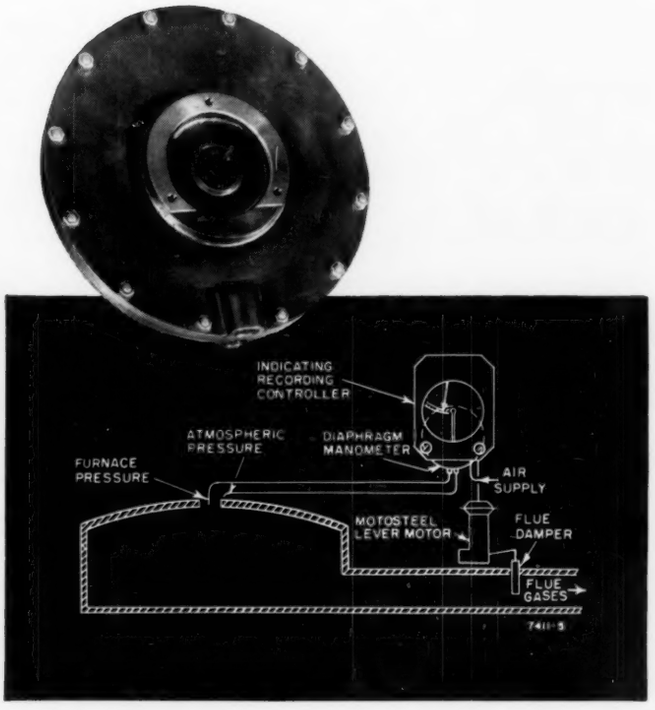
Words like these tell the story of Taylor Instruments and Taylor Control Systems in use in iron and steel plants across the country. These words—and ones like "lower production costs . . . consistently higher product quality . . . greater operating efficiency."

Here are two Taylor Systems that are hard at work today in plants like yours. They are two of many practical Taylor applications that are keeping costs down and keeping quality high for men who process metals and by-products.

Today's advanced methods of metals production and processing have increased the demands for automatic control. For specific suggestions on how Taylor can help you meet these demands, call your Taylor Field Engineer or write for **Bulletin 98261.** Taylor Instrument Companies, Rochester, N. Y., and Toronto, Ontario.



Taylor TRANSET* Potentiometer Transmitters applied to a Heat Treating Furnace. Converts a DC primary electrical signal into a 3-15 psi pneumatic output for controllers and receivers. Continuous, electronic standardization eliminates slide wires, batteries and moving parts. "Plug-in cans" permit instant conversion from one type of service to another.



Taylor Diaphragm Manometer for Furnace Pressure or Draft Control. Particularly suited for accurate low pressure measurement of air or gas, static or differential, with operating ranges as low as minus 0.5 to plus 0.5 inches or up to 0 to 4 inches of water. For close fitting on back of Taylor indicators, recorders, controllers or transmitters.

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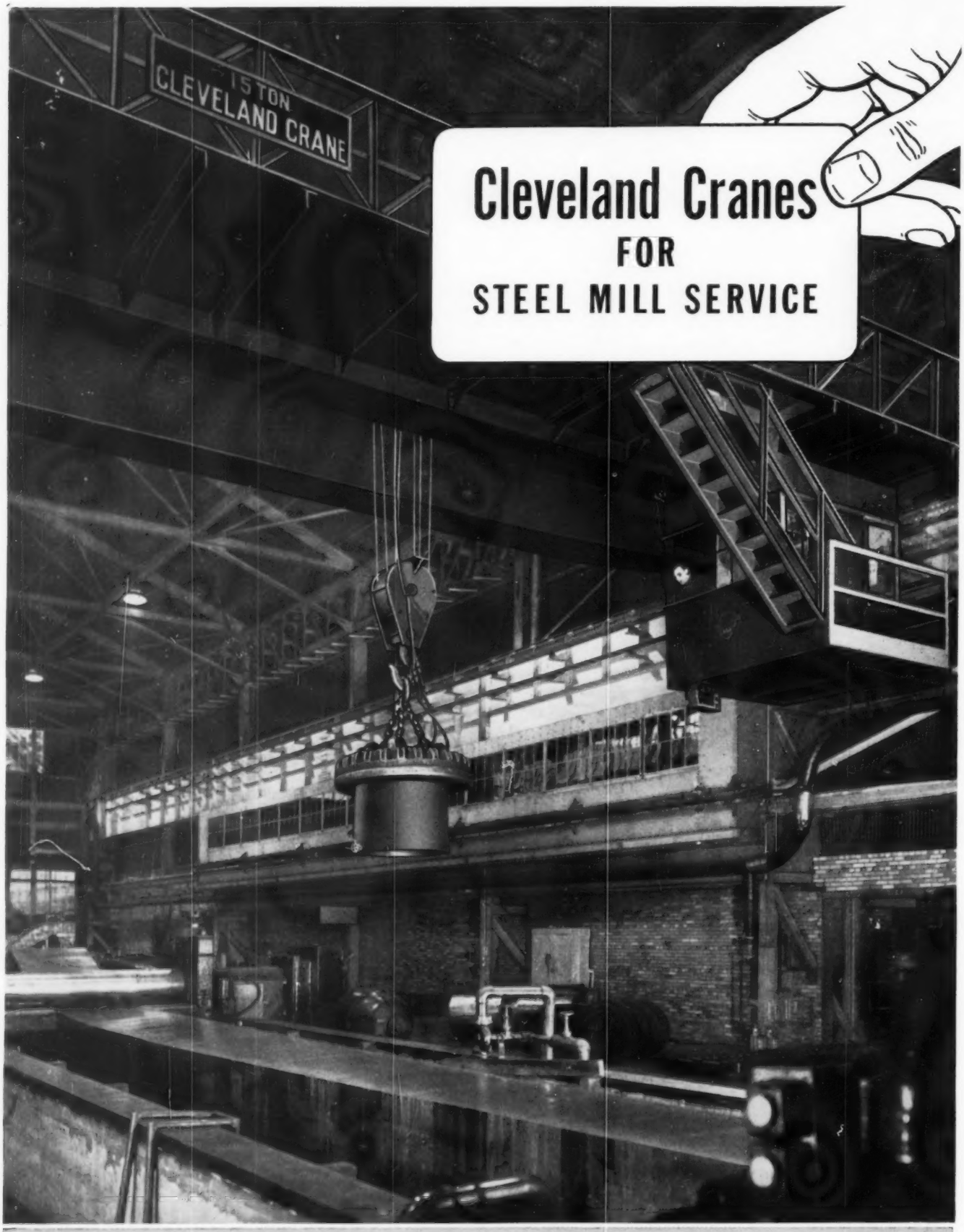

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Crops *and* Shorts

△ Now that the New Year's resolutions have been broken, even though we're still not writing 1958 without conscious effort, it's time to look around and see where we're headed.

Year-end statements by industrial leaders reflect a cautious optimism. Steel predictions for 1958 range 100,000,000 to 107,000,000 tons of ingots. A first half figure of 50,000,000 tons seems most favored, with the second half running 5 to 10 per cent higher.

The Value Line Investment Survey makes this prediction: "A combination of reduced customer demand and continued liquidation of inventories in manufacturing channels is expected to result in an 11 per cent decline in steel production next year. Prices are likely to average slightly higher than during 1957, thereby limiting the slump in dollar sales volume to about 9 per cent. Steel company profit margins will inevitably contract as production limps along far below capacity. Earnings may fall some 20 per cent in the aggregate; much wider declines are in prospect for several companies. A number of established dividend rates are likely to be reduced."

△ Roger M. Blough, chairman of United States Steel Corporation, believes the current decline in steel operations not as important as the problems of wage increases in excess of productivity and the inadequacy of depreciation recovery allowed by tax laws.

△ An experienced old timer says a wise husband never contradicts his wife. He just waits a while and she'll contradict herself.

And just to prove he's an old misogynist he condenses a bride's thoughts as the organ plays the wedding march as: "Aisle-Altar-Hymn."

△ It seems too bad that an important industry should permit such a situation to develop, but automobile pricing has become so confused that businesses have been set up which will sell you, for one dollar, the prices of the make of car and its accessories in which you are interested.

△ Meanwhile, the auto industry is sulking in aggrieved wonderment because the public isn't breaking down the door to buy its misshapen monsters.

If the industry really canvassed its best prospects, they would find the majority want a car: High enough to sit in without crushing our hats against the roof, designed to eliminate the contortionist act getting in an out, and with enough road clearance to prevent making like a road scraper in every little snow storm.

Not over 76 or 77 in. overall width, so our garages remain useful.

About 12 to 18 in. shorter than the present space hogs.

With less chrome or stainless trim.

With only one pair of headlights, tail lights, stop lights—and perhaps no back-up lights.

Without the distorted fins, lumps and protuberances that sin against modern functional design.

With less gadgetry and more dependability and accessibility.

With better economy.

And with the price reduced in line with these changes.

△ Sputnik will do more good for the United States than for Russia if the resulting furor about American educational curricula and methods turns out to be anything more than wind in the trees.

For a good many years we have had a pet peeve against the so-called progressive methods that turn out students who can't spell, who can't get into college and who haven't even learned how to study. High school curricula are cluttered with "snap" courses which may be elected in place of courses of real value in preparation for further study.

If Sputnik brings a return to high school courses with 12 or 14 required credits, to more home work, to stiffer scholarship requirements and to more discipline, it will have been worthwhile.

△ The Wall Street Journal observes that folks who live within their incomes are just trying to mess up prosperity.

△ The Capital Goods Review, a publication of Machinery and Allied Products Institute, points out three developments in U. S. capital equipment exports during the past decade:

Actual physical volume of annual exports did not go up appreciably, notwithstanding the large increase in dollar volume.

The importance of European and South American markets has declined, while exports to Canada increased. Africa, Asia and Central America show no appreciable change.

Industrial machinery has increased its share of total equipment exports from 49 to 59 per cent.

△ A Los Angeles correspondent suggests that, since fines have not solved the traffic violation problem, we might try impounding offenders' cars for a few days.

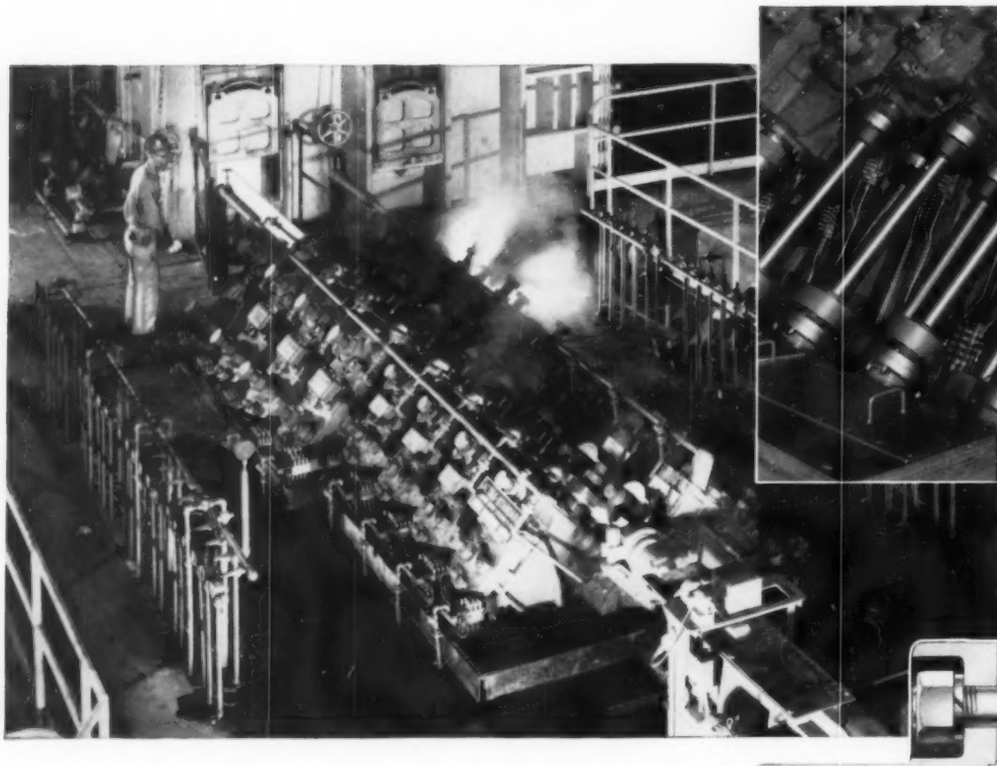
△ According to the Institute of Scrap Iron and Steel, steel mills and foundries in the United States used about 36,300,000 tons of home scrap and 30,000,000 tons of purchased scrap. Licensed exports of scrap totaled 5,600,000 tons.

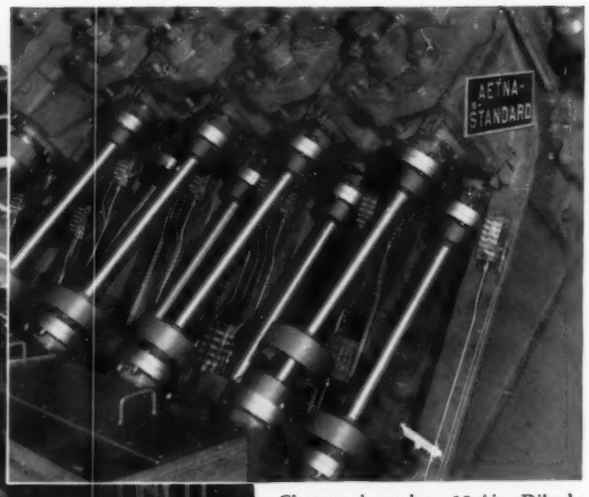
△ A southern correspondent tells us that mistletoe is bad for trees. Bad for trees, maybe, but fun for two's.

△ A hard job is too often just the sum total of a lot of easy things that weren't done when they should have been.

32 AJAX DIHEDRAL COUPLINGS

HELP STRETCH-REDUCE STEEL TUBING





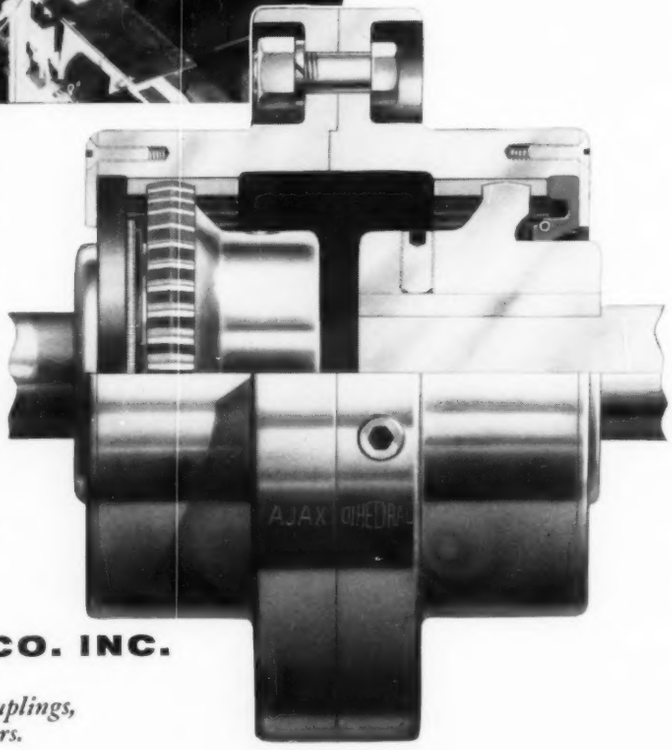
Closeup shows how 32 Ajax Dihedral Floating Shaft Couplings operate at 8°10 min. plus or minus. Note how they are clustered in minimum. space.

Aetna-Standard engineers are taking advantage of the ability of Ajax Dihedral Couplings to operate at the required angle between driving and driven components of this 16 stand stretch reducing mill. This heavy-duty mill reduces approximately 7" tube down to 2" tubing.

Constant peripheral velocity of Ajax Dihedral Couplings produces tubing by the mile with diameters and wall thicknesses held to close tolerance.

This is another example of how machinery manufacturers are taking advantage of Ajax Dihedral Couplings to meet exacting design requirements involving angular and offset alignment up to a total of 12 degrees.

Ajax Sales Representatives are qualified by training and experience in field engineering and application problems...it will pay you to get the latest thinking on power transmission with Ajax Dihedral Couplings.

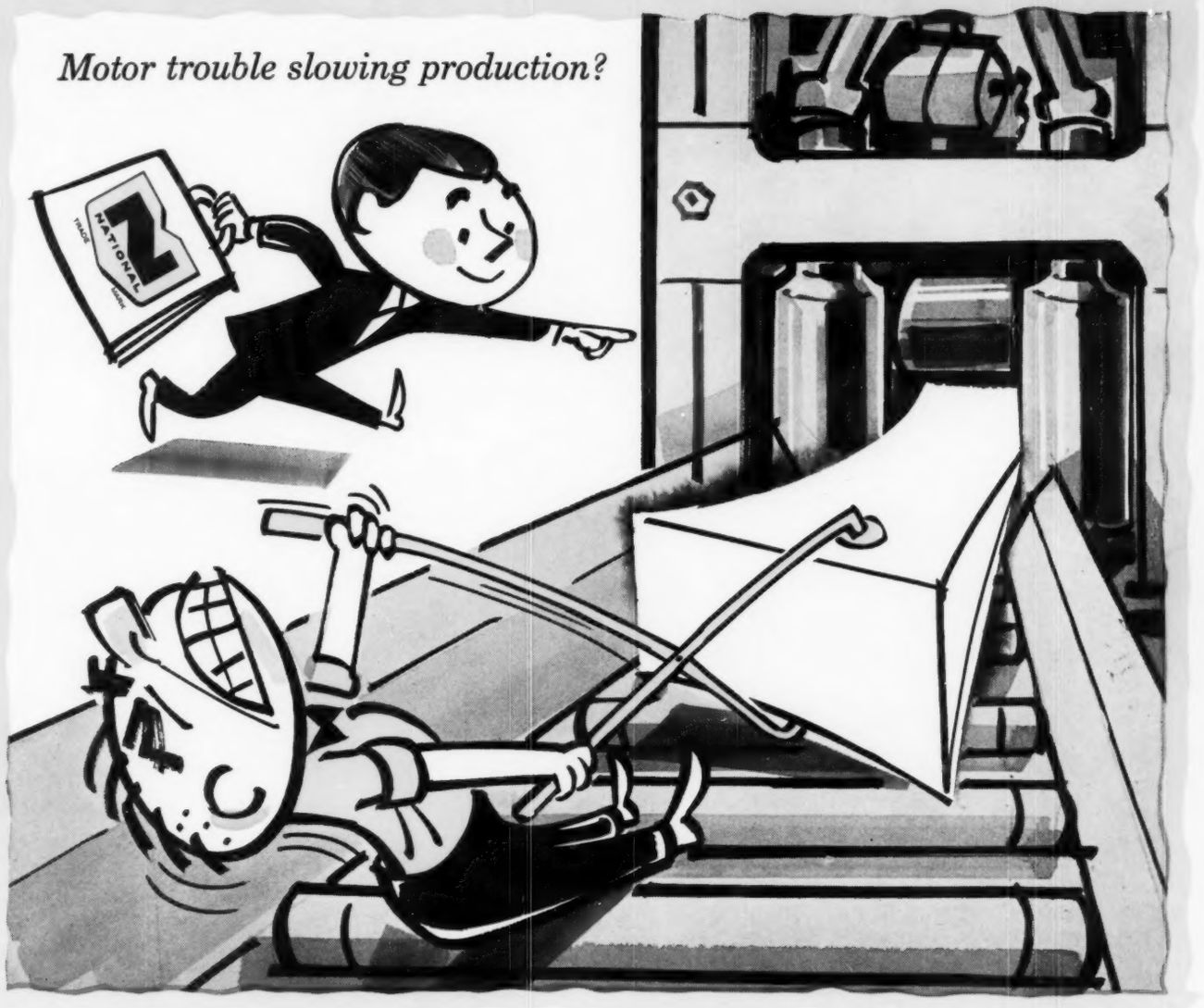


AJAX FLEXIBLE COUPLING CO. INC.

WESTFIELD. N. Y.

Also manufacturers of rubber-bronze cushioned couplings, vibrating conveyors, screens, feeders and packers.

Motor trouble slowing production?



Your NATIONAL brush man helped solve this slowdown problem!

JOHN BEHEN

Motor trouble at this 44″ steel mill caused one costly slowdown after another, says "National" Carbon Brush Man, John Behen. Source of the production trouble – excessive film build-up on one of the mill's edger motors.

The mill tried several brushes to alleviate this condition but with no success. They called in John Behen who analyzed the operation and recommended the proper "National" brush grade. *Result:* a 100 ton increase in daily production thanks to trouble-free motor performance. Incidentally, John went on to solve similiar brush problems on 3 of the steel mill's 5,000 amp motor-generator units.

John Behen and his fellow "National" Carbon Brush Men have been solving industrial brush problems for years. Their experience and training – backed by "National" *long term brush development* – make them the logical consultants on any industrial brush problem.

Call your "National" Carbon Brush Man today. Or write National Carbon Company, Division of Union Carbide Corporation, 30 E. 42nd St., New York 17, N.Y.

The terms "National", "N" and Shield Device, and "Union Carbide" are registered trade-marks of Union Carbide Corporation

UNION CARBIDE

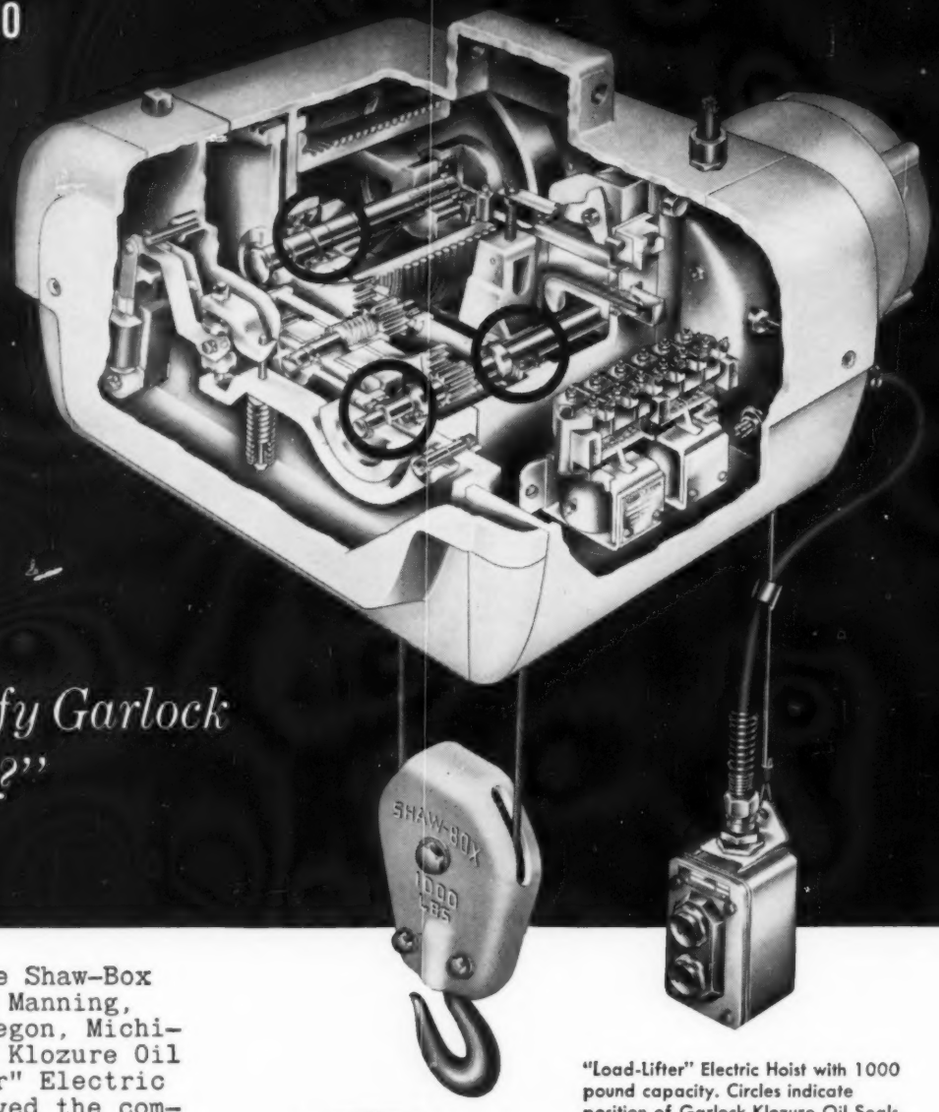
NATIONAL CARBON COMPANY • Division of Union Carbide Corporation • 30 East 42nd Street, New York 17, N. Y.

Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco. *In Canada:* Union Carbide Canada Limited, Toronto.

MORE OF THE GARLOCK 2,000

We Asked MANNING, MAXWELL & MOORE:

"Why do you specify Garlock Klozure Oil Seals?"*



"Load-Lifter" Electric Hoist with 1000 pound capacity. Circles indicate position of Garlock Klozure Oil Seals.

For the past five years, the Shaw-Box Crane and Hoist Division of Manning, Maxwell & Moore, Inc., Muskegon, Michigan, have specified Garlock Klozure Oil Seals for their "Load-Lifter" Electric Hoists. Recently, we surveyed the company to find what benefits they received by specifying Garlock.

Here is their reply:

"We use Klozure Oil Seals for three primary reasons.

1. dependability. Our hoist is designed for heavy duty use. A failure in any oil seal would shortly render the hoist inoperable. Therefore, we must use oil seals consistent with the quality built into the entire hoist.
2. long-life. The oil seal must permit easy maintenance and be reusable after hoist repair since replacement of oil seals during a minor overhaul is undesirable.
3. standardization. The fact that Garlock can meet nearly every oil seal requirement permits us to attain greater standardization of hoist components."

Cross section of Model 51 Garlock Klozure Oil Seal designed for medium-speed rotary service and low pressure reciprocating service. Two of these seals are used on the motor pinion shaft and a specially designed Klozure Oil Seal on the rope drum of the Electric Hoist illustrated above.

Garlock Klozure Oil Seals can serve your company equally well. Ask your Garlock representative for his recommendation from "the Garlock 2,000" . . . two thousand different styles of packings, gaskets and seals for every need. Or write for Klozure Catalog 20.

THE GARLOCK PACKING COMPANY, Palmyra, N.Y.

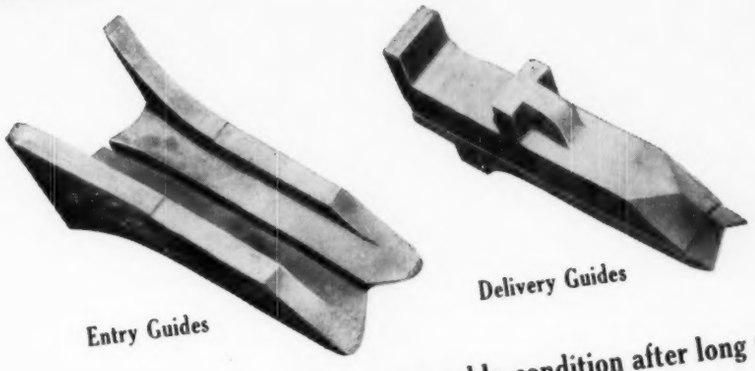
For prompt service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

TRANTINYL GUIDES
THE STEEL INDUSTRY

Steel Producers amazed at HIGH TONNAGE rolled with TRANTINYL GUIDES



Entry Guides

Delivery Guides

Two pair of angle guides, still in serviceable condition after long usage

These entry and delivery guides on 12" mill were photographed in a midwest steel plant after rolling unusually high tonnage. Guides showed no noticeable signs of wear and proved again the outstanding durability of "TRANTINYL." If you have not yet tested "Trantinyl" guides to your own satisfaction, why not try them now.

12" Mill showing Entry Guides

"Trantinyl" Guides and Rollers hold exceptionally high tonnage performance records, in serving leading steel mills for a quarter-century. Rolling more than 100,000 tons over a single pair of guides has been recorded.

Guides for Rolling Mills • Tube Mills
Straightening Machine Guides
Heat-Resisting "Trantinyl" Cast-to-Shape

Youngstown Alloy Casting Corporation

Youngstown, Ohio

Sole Licensee to cast "TRANTINYL" for the Midwest, West and South: WAUNAKEE ALLOY CASTING CORP., Waunakee, Wis.

Why the LINK-BELT Series 100 is

TODAY'S MOST WIDELY ACCEPTED BELT IDLER

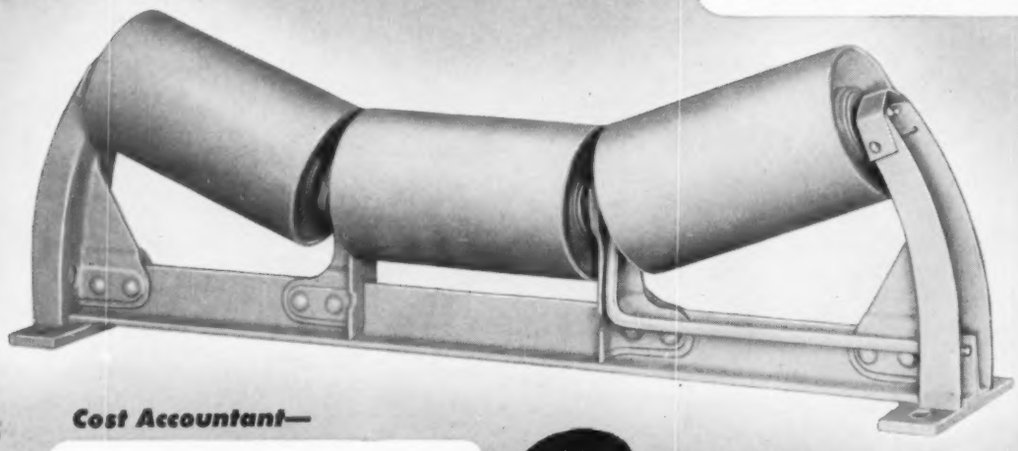
Here's what men who know idlers have to say

Superintendent—

"Service records of the Link-Belt Series 100 belt conveyor idler show that there's no more durable belt conveyor idler in the capacity range. It's a 'work horse'—gives economical service under hard duty, conveying all but the heaviest and coarsest materials."

Engineer—

"Look at these design features. Self-contained, concentric rolls with bearings fully enclosed and protected... strong heavy ribbed brackets and sturdy rigid frames maintain accurate roll alignment—won't spread under load . . . hex nuts that lock rolls in brackets, preventing shaft rotation."



Cost Accountant—

"All costs considered—installation, operation and maintenance. You won't find a better buy in belt conveyor idlers than the Link-Belt Series 100. Its free-rolling action requires less power . . . reduces wear on operating parts and belt . . . cuts replacements."

Maintenance Man—

"Its cartridge seal is the best I've seen . . . has no springs, clips and other small parts to lose . . . cuts servicing time when required. It's tops for keeping grease in, dirt out under the grimiest conditions. Grease fittings are protected, easy to reach."

Broad range of types meets all material and operating requirements

RUGGED . . . free-rolling . . . dirt- and dust-proof—the Link-Belt Series 100 belt conveyor idler combines these and other features for low-cost, dependable materials handling under severe, continuous service conditions. What's more, you have a wide choice of types for any requirement—whether you handle coal, sand, gravel or iron ore . . . sticky or free-flowing materials.

Sturdy rolls of the Series 100 are accurately machined for concentricity—welded for added strength and to keep out dirt and moisture. Smooth, round surfaces and edges prevent belt damage. As for dependability of its roller bearings—Link-Belt has *never* known a bearing failure due to overloading a Series 100 idler. Equally important, strong malleable iron brackets and sturdy, rigid frames maintain accurate roll alignment.

For facts on the Series 100 belt conveyor idler, see your nearby Link-Belt office or authorized stock-carrying distributor. Or write for Book 2416.

LINK-BELT

BELT CONVEYOR IDLERS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,493

UNITED®

6 stand continuous horizontal and vertical Billet Mill

UNITED ENGINEERING AND FOUNDRY COMPANY
Pittsburgh, Pennsylvania

Plants at PITTSBURGH • VANDERGRIFT • YOUNGSTOWN • CANTON • WILMINGTON

Subsidiaries: ADAMSON UNITED COMPANY, AKRON, OHIO
STEDMAN FOUNDRY AND MACHINE CO., INC., AURORA, INDIANA

Designers and Builders of Ferrous and Nonferrous Rolling Mills, Mill Rolls, Auxiliary Mill and Processing Equipment, Presses and other Heavy Machinery. Manufacturers of Iron, Nodular Iron and Steel Castings, and Weldments.

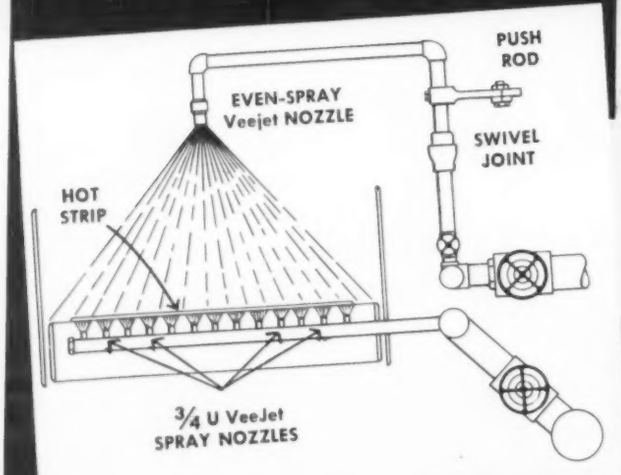
SPRAYING SYSTEMS

SPRAY NOZZLES

FOR

Hot Strip Spray Cooling

• AND ROUGHING STAND ROLL COOLING, **DESCALING** AND RELATED SPRAYING OPERATIONS

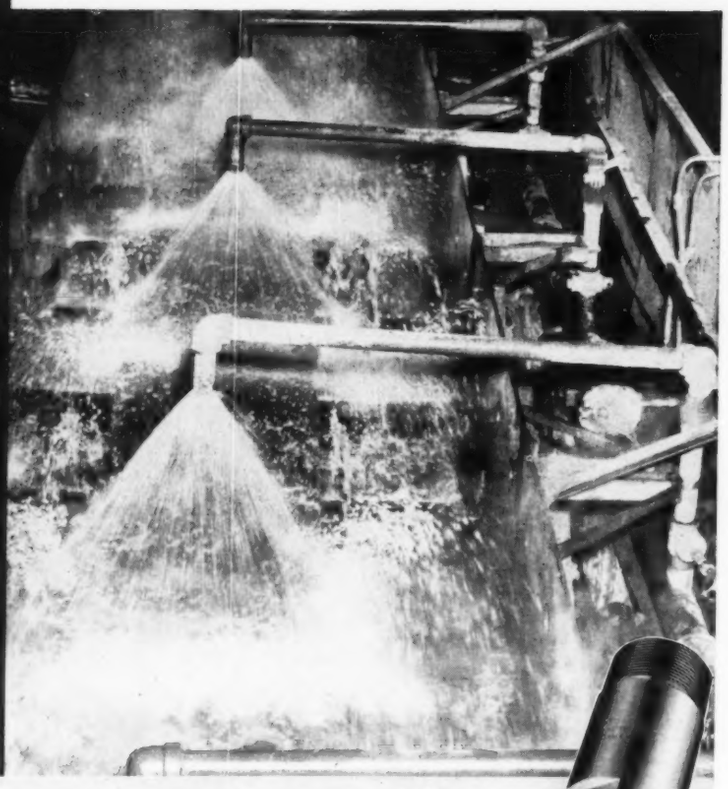


AT THE

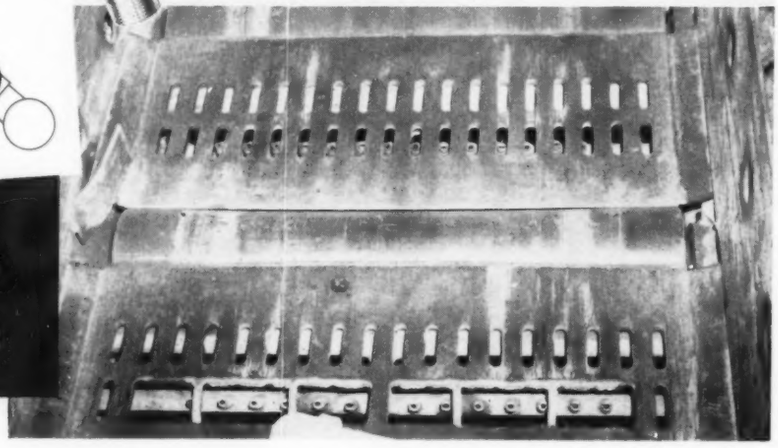
PORTSMOUTH DIVISION PLANT

PORTSMOUTH, OHIO OF THE

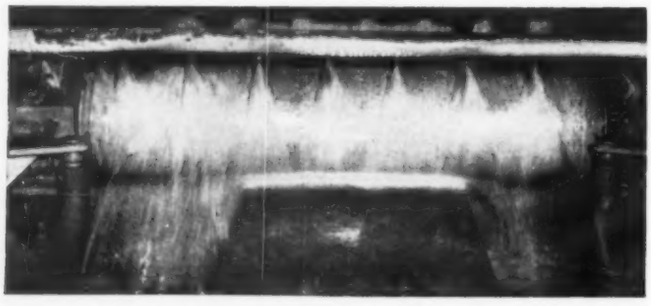
DETROIT STEEL CORPORATION



• Large capacity Even-Spray VeeJet Spray Nozzles are mounted above the cooling table. Each nozzle covers entire strip width . . . provides 170 GPM at 80 psi. Smaller VeeJet nozzles are mounted in manifolds below table; capacity of each nozzle is 14 GPM at 5 psi.



• One of the most interesting nozzle installations at Detroit Steel's Portsmouth plant is the system for cooling hot strip. Using Spraying Systems nozzles above and below the first 120′ of the 360′ runout table length, effective steam barrier penetration helps reduce strip temperature as much as 500 degrees between finishing stand and coiler. Cobbles cannot endanger the system since the overhead nozzles are gang mounted on risers with swivels, and swing out of the way when necessary. Not one nozzle has been lost or replaced in over six months of operation. For greater efficiency and lower costs, Spraying Systems nozzles are also employed in such other applications as descaling . . . and roll cooling as shown at left. For complete information on Spraying Systems spray nozzles, we invite your inquiry for Catalog 24 . . . or for the special data sheet folder "Steel Mill Applications."



SPRAYING SYSTEMS CO.

3262 RANDOLPH STREET • BELLWOOD, ILLINOIS

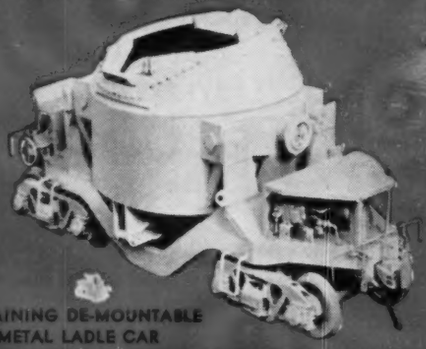
Pollock Experience at No Extra Cost

The William B. Pollock Company has been serving the iron and steel industry the world over since 1863.

Pioneers in heavy steel work, Pollock is excellently qualified, equipped and staffed to design and build your special heavy-duty equipment.

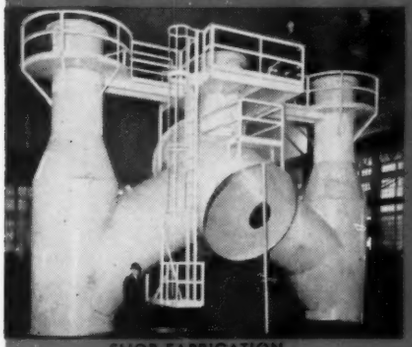
Pollock is known for its reliable, efficient precision work. You, too, can benefit from Pollock's broad experience.

BLAST FURNACE CINDER CAR
AND OPEN HEARTH SLAG CAR



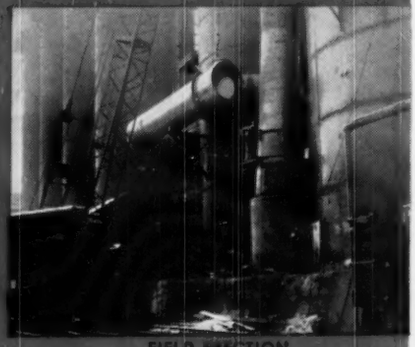
HEAT RETAINING DE-MOUNTABLE
HOT METAL LADLE CAR

PICTURED ABOVE IS POLLOCK FIELD ERECTION EQUIPMENT IN THE PROCESS OF ERECTING A MODERN BLAST FURNACE



SHOP FABRICATION

WELDED OPEN HEARTH LADLE

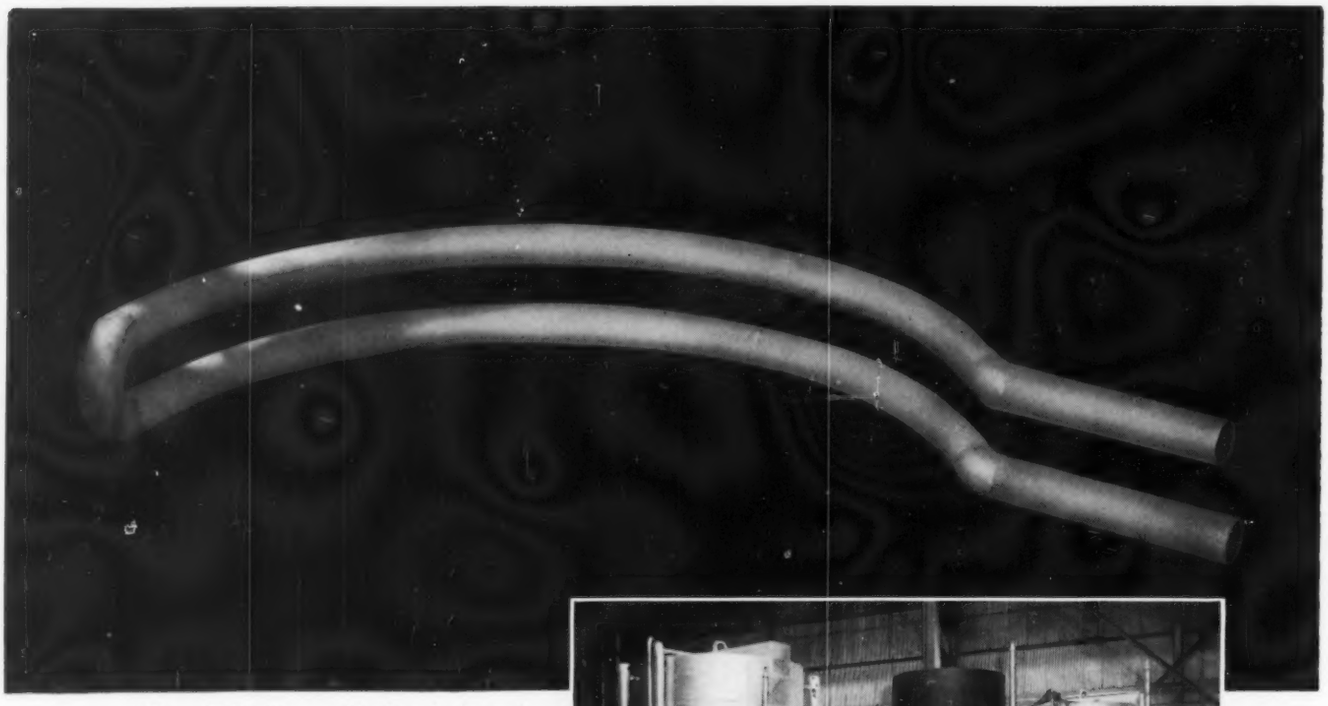


FIELD ERECTION

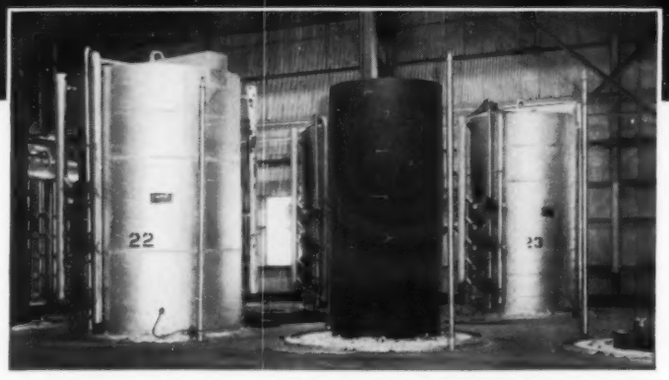
POLLOCK
SINCE 1863

THE WILLIAM B. POLLOCK COMPANY
YOUNGSTOWN · OHIO
STEEL PLATE CONSTRUCTION · ENGINEERS · FABRICATORS · ERECTORS

BLAST FURNACES • HOT METAL CARS AND LADLES • CINDER AND SLAG CARS • INGOT MOLD CARS • CHARGING BOX CARS • WELDED OPEN HEARTH LADLES



"Curved-Tube" assembly for single-stack annealer, centrifugally cast of Thermalloy high-heat-resistant alloy.



SPECIALLY DEVELOPED

for single-stack annealing furnaces

THERMALLOY* CURVED RADIANT TUBE ASSEMBLIES

Keeping pace with the growth of single-stack annealing, Electro-Alloys technicians, co-operating with furnace manufacturers, have developed a method of utilizing centrifugally cast tube in a curved radiant tube assembly.

The centrifugally cast tube offers many advantages inherent in this casting process—greater density, better grain structure, and uniform thickness—all of which add up to greater strength and longer service life. Now these advantages are available to you for employment in your single-stack annealing furnaces through the use of these new curved radiant tubes.

Curved radiant tube assemblies are typical of our continuing effort to develop products designed to fit the changing needs of the steel industry. We would like to work with you to develop Thermalloy castings for *your* high-heat application. Please contact your local Electro-Alloys representative or write us here at Electro-Alloys Division, 9061 Taylor St., Elyria, Ohio.

**Reg. U. S. Pat. Off.*

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION Elyria, Ohio

patent reviews

By MELVIN NORD, Patent Attorney, Detroit, Mich.

Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents reviewed cover period August 6, 1957 through August 27, 1957.

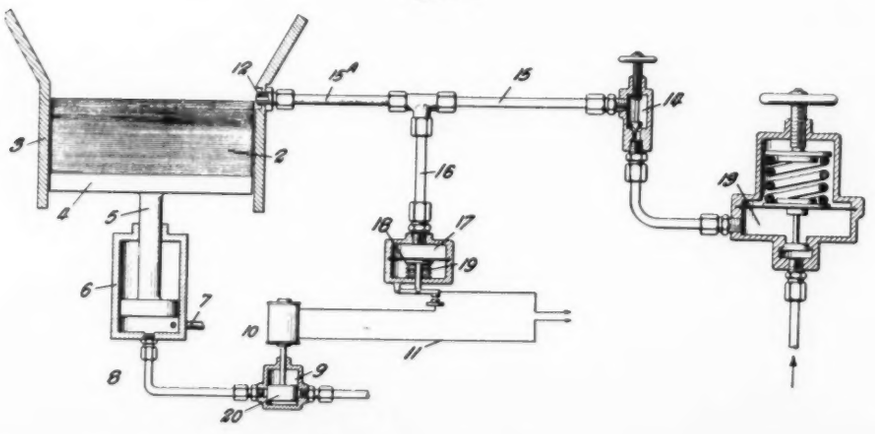
HEIGHT LEVEL CONTROL FOR SHEETS BEING STACKED

△ U. S. 2,801,756, issued Aug. 6, 1957 to Calvin L. Vansickle and assigned to Dominion Foundries and Steel Ltd., describes a device for automatically controlling the height level of stacked steel sheets which are being delivered from sheet shearing apparatus.

The operation of the device is shown in Figure 1. When the top sheet of the stack 2 is at the required level, air ejection through nozzle 12 is unobstructed. However, when additional sheets are added to the top of the stack, their side edges form an obstruction against free air flow from the nozzle, thus causing a slight back pressure in the piping 15 and 16, which back pressure is sufficient to close the air pressure switch 17. Closure of switch 17 energizes the solenoid 10 to open valve 9 and permit fluid to bleed from cylinder 6 through pipe 8, causing ram 5 gradually to drop, until the side edges of the top sheets are below the path of air ejection from the nozzle. When this occurs, the back pressure in the piping 15 and 16 is relieved, permitting switch 17 to open under the pressure of spring 19, to de-energize solenoid 10, and to close valve 9.

As further sheets are delivered to the stack, this operation is repeated. To provide for any desired height adjustment, the portion 15A of the piping is made of flexible material, to permit adjustment of the nozzle 12 in the stack enclosure.

Figure 1



MIXING OF BLAST FURNACE FINES WITH COKING COAL

△ U. S. 2,801,913, issued Aug. 6, 1957 to Joseph Becker, assigned to Koppers Co., Inc., discloses an improvement in the process of mixing blast furnace fines with coking coal, which minimizes the amount of sulphur returned to the blast furnace, without adversely affecting the by-product yields of ammonia and tar.

The improvement consists of dividing the coal charge destined for the coking chambers into major and minor portions, mixing the blast furnace fines with the minor portion of the coal (the blast furnace fines being present in a concentration of 20 to 65 per cent in this minor coal portion), coking the major straight coal portion and the minor coke-fine blend separately, and then blending the coked products. The result is a substantial increase in the amount of H_2S recovered in the by-product gases, and a corresponding decrease in the amount of sulphur left in the coke.

The patent cites examples, which indicate that in this manner the sulphur content of the coke can be reduced from 1.61 per cent (in the case of straight blending of blast furnace fines and coking coal) to 1.26 per cent.

INHIBITOR ACID PICKLING

△ U. S. 2,801,979, issued Aug. 6, 1957 to Karl F. Hager, Josef M. Michel, and Morris Rosenthal, assigned to Secretary of the Army, describes a method for inhibiting the corrosive effects of acid upon the metal, in acid pickling processes.

The inhibitor added to the bath is the sodium salt of alkyl (C_{12-18}) -sulphamidoacetic acid, sometimes called mepasin - sulphamido - acetic acid.

Tests with and without the inhibitor showed respective losses of iron of 0.7 and 22.6 per cent by weight. Thus, the inhibitor effectiveness is about 96 per cent.

APPARATUS FOR CHARGING A BLAST FURNACE

△ U. S. 2,802,661, issued Aug. 13, 1957 to Kenneth C. Mc Cutcheon, assigned to Reserve Mining Co., describes an improvement in the method of charging a blast furnace, so as to avoid difficulties such as slips, hanging, and excessive coke consumption due to improper contact of the ascending gases and the descending solid materials.

Improved distribution of the materials charged, and hence improved permeability in the stock column

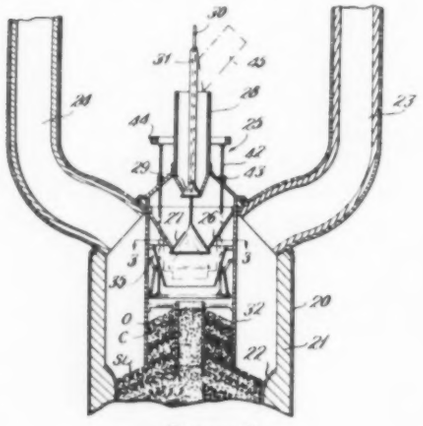


Figure 2

and better gas-solid contact, is accomplished by changes in the top of the furnace and changes in the charging method. Thus, irregularities in distribution of the material over the smaller bell, due to the delivery to it by the skip or bucket, are equalized by making the cross-sectional area of the upper hopper smaller than in conventional constructions or alternatively, means are provided in the upper hopper or supply tube to assist the distribution of the material in it. Consequently, the material is delivered to the charging bell with a substantially uniform circumferential distribution. In addition, the larger or charging bell is operated separately for each different type of material delivered, i.e., for ore, flux, and coke, so that the different materials are charged sequentially in layers into the furnace. Alternatively, the ore, flux, and coarse coke may be deposited on the large bell and charged together into the furnace by one drop or operation of the large bell. Furthermore, the upper portion of the furnace is so arranged that the materials dropped into it do not fall against rising currents of gases, but instead enter a relatively quiescent zone and, as shown in Figure 2, the materials are so directed they fall as to aid their distribution and direct them to desired locations. Moreover, the quiescent zone is so arranged as to provide a constant head of material within the blast furnace proper, which is unaffected by the sequential operation of the bells. In addition, the area of the quiescent zone is so related to the areas of the smelting and tuyere zones that the flow of gases is not impeded and the materials moving from the quiescent zone substantially maintain their initial distribution within the upper portion of the furnace proper.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

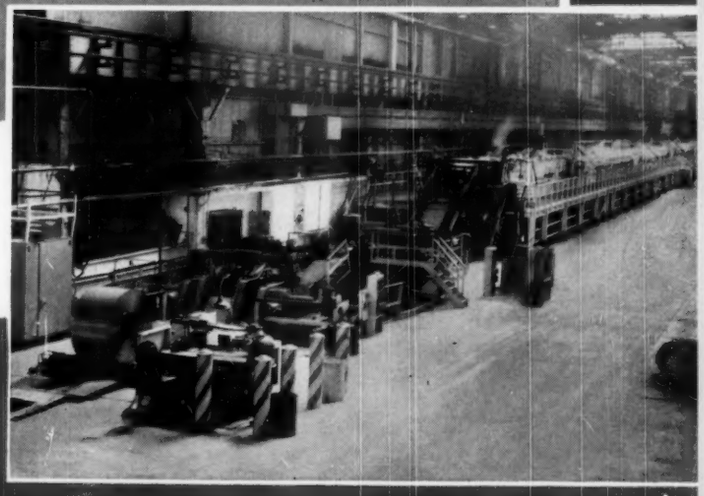
Patent No.	Date	Subject	Inventor or assignee
2,801,457	8/6/57	Ball separating means for ball rolling machines	Armco Steel Corp.
2,801,693	8/6/57	Apparatus for making an endless belt with a central internal groove	United States Steel Corp.
2,801,755	8/6/57	Controlled slack coupler	American Steel Foundries
2,801,916	8/6/57	Ferrous alloys for high temperature use	William Jessop & Sons, Ltd.
2,801,942	8/6/57	Method of rendering an aluminum-iron alloy ductile	Secretary of the Navy
2,802,586	8/13/57	Coil transfer mechanism	E. W. Bliss Co.
2,802,656	8/13/57	Element for insulating the surface of a molten product	Jean R. V. Martiny
2,802,657	8/13/57	Fast heat and soak furnace for extrusion	Surface Combustion Corp.
2,802,725	8/13/57	Endothermic gas generator	Victor V. Kappel
2,802,730	8/13/57	Production of low-carbon ferrochromium	Chromium Mining & Smelting Corp., Ltd.
2,802,761	8/13/57	Method of making rolled ferrosilicon alloys	North American Philips Co., Inc.
2,802,778	8/13/57	Dry quenching station arrangement for coke	Koppers Co., Inc.
2,803,215	8/20/57	Apparatus for lubricating the external surface of an extrusion billet	The Babcock & Wilcox Co.
2,803,535	8/20/57	Blowing steel with oxygen-containing gas	Kloeckner-Huettenwerk Haspe, A. G.
2,803,538	8/20/57	Self-hardening alloys	Coast Metals, Inc.
2,803,539	8/20/57	Fe-Cr-Ni alloys	William Jessop & Sons, Ltd.
2,803,587	8/20/57	Method of heat treatment, separation, and coking coal	Frederic W. Jung
2,803,592	8/20/57	Coke oven door	Sadao Shimazaki
2,803,863	8/27/57	Method of improving the cutting speeds of carbon steels and ferrous alloys	Alexander Paudrat
2,803,987	8/27/57	Measurement of the variations of opacity of a converter	Institute de Recherches de la Siderurgie
2,804,039	8/27/57	Hatch cover for ore carrier	American-Hawaiian Steamship Co. (Del.)
2,804,058	8/29/57	Water-cooled door frame for open hearth furnaces	Reliance Steel Products Co.
2,804,196	8/27/57	Device for descaling and cleaning wire rod	Earl C. Planett
2,804,295	8/27/57	Apparatus for preheating and conditioning scrap metal	Frank W. Brooke
2,804,385	8/27/57	Refining of phosphorus-containing pig iron	Huttenwerk Oberhausen A. G.
2,804,387	8/27/57	Preparation of iron-aluminum alloys	Ford Motor Co.
2,804,411-3	8/27/57	Carburization of metal rods	Gardner-Denver Co.
2,804,428	8/27/57	Reversal apparatus for regenerative ovens	Koppers Co., Inc.
2,804,493	8/27/57	Automatic regulation of electric arc furnaces	Whiting Corp.

PRODUCTION OF BESSEMER STEEL

△ U. S. 2,802,731, issued Aug. 13, 1957 to Karl Heimberg and Erich Lanzendoerfer, assigned to Compagnie Generale des Conduites d'Eau, describes a process of produc-

HIGH-SPEED CONTINUOUS PICKLING LINES

Designed and Built by MESTA



MESTA HIGH-SPEED CONTINUOUS PICKLING LINES WITH TRIMMERS, UP-COILERS AND MESTA-THOMSON FLASH WELDERS

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY · PITTSBURGH, PA.

Name your bearing needs...we'll meet 'em pronto from 30 types, 10,247 sizes

TIME and time again, machinery makers come to the Timken Company for help with some special bearing application problem. One they think hasn't been solved before. And time after time, from our 30 types and 10,247 sizes of Timken® tapered roller bearings, we've come up with the bearing design to do the job and at minimum cost.

It's no accident that we can help out so often. In over 50 years of helping machinery builders with bearing problems, we've engineered and produced the world's largest selection of tapered roller bearings. And we've constantly improved our designs. The answers to thousands of bearing application problems are already in our files. Ready and available to help you.

And machine users get the same swift service if they ever need a replacement Timken bearing. Even for old machines, they can almost always count on immediate delivery of Timken bearings for replacement.

Why not call on our engineers for help whenever you have a bearing application problem or requirement? Timken is your No. 1 bearing value. Wherever wheels and shafts turn, Timken bearings eliminate friction, cutting wear and maintenance to a minimum. Specify bearings trade-marked "Timken" for the machines you buy or build. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ont. Cable: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS ROLL THE LOAD

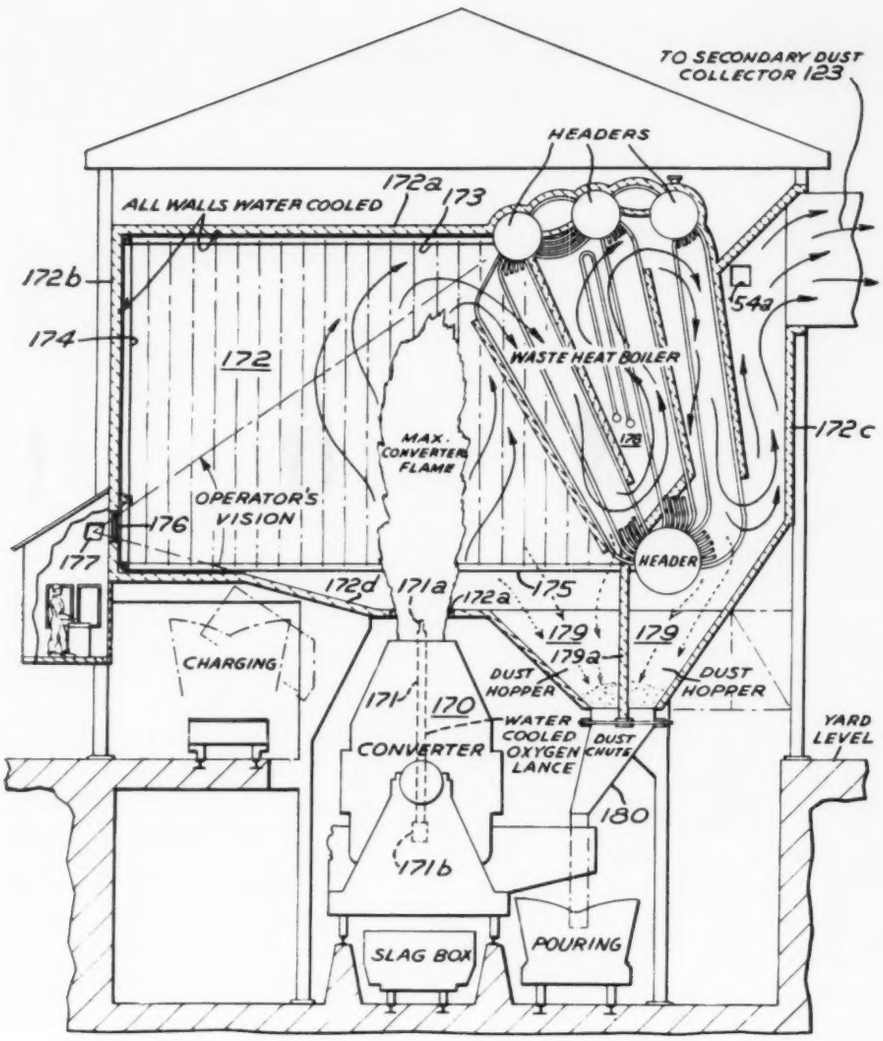


Figure 3

ing bessemer steel without the necessity of first producing a special bessemer pig iron rich in silicon and manganese.

The process consists of introducing into a cupola furnace an iron-containing material containing impurities (e.g., iron turnings, or a pig iron high in sulphur and phosphorus) with an excess of coke, and passing into the cupola a blast of air heated to 500 to 600 C. The carbon in the charge is oxidized so as to attain a working temperature of at least 1500 C, and a reducing atmosphere is maintained due to the excess of carbon. The iron-containing material is thus melted in a reducing atmosphere while preventing formation of iron oxides, and is passed through a molten basic slag at a temperature of at least 1500 C, so as to remove impurities and form substantially pure molten iron, with about 3 per cent carbon. This molten iron is immediately charged to a bessemer converter and subjected to a hot blast for about 15 minutes, to produce a bessemer steel having high qualities, particularly due to the extremely low silica content of the steel.

BESSEMER CONVERTER GAS CLEANING SYSTEM

△ U. S. 2,803,450, issued Aug. 20, 1957 to Harry L. McFeaters, assigned to Pennsylvania Engineering Corp., describes a bessemer converter layout which cloaks the flame and avoids atmospheric air contamination from its gas, fume, and smoke discharge.

According to the inventor, his method makes possible the use of air for cooling the effluent gases and for oxidizing the carbon monoxide and the metal fumes, without the formation of explosive mixtures.

One form of the apparatus is shown in Figure 3. In this modification, a water-cooled oxygen lance 171 is used instead of the combustion air used in the other modifications described.

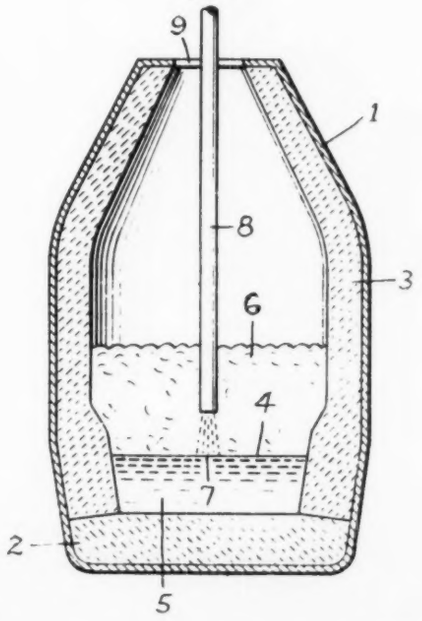
OXYGEN PROCESS FOR STEEL PRODUCTION

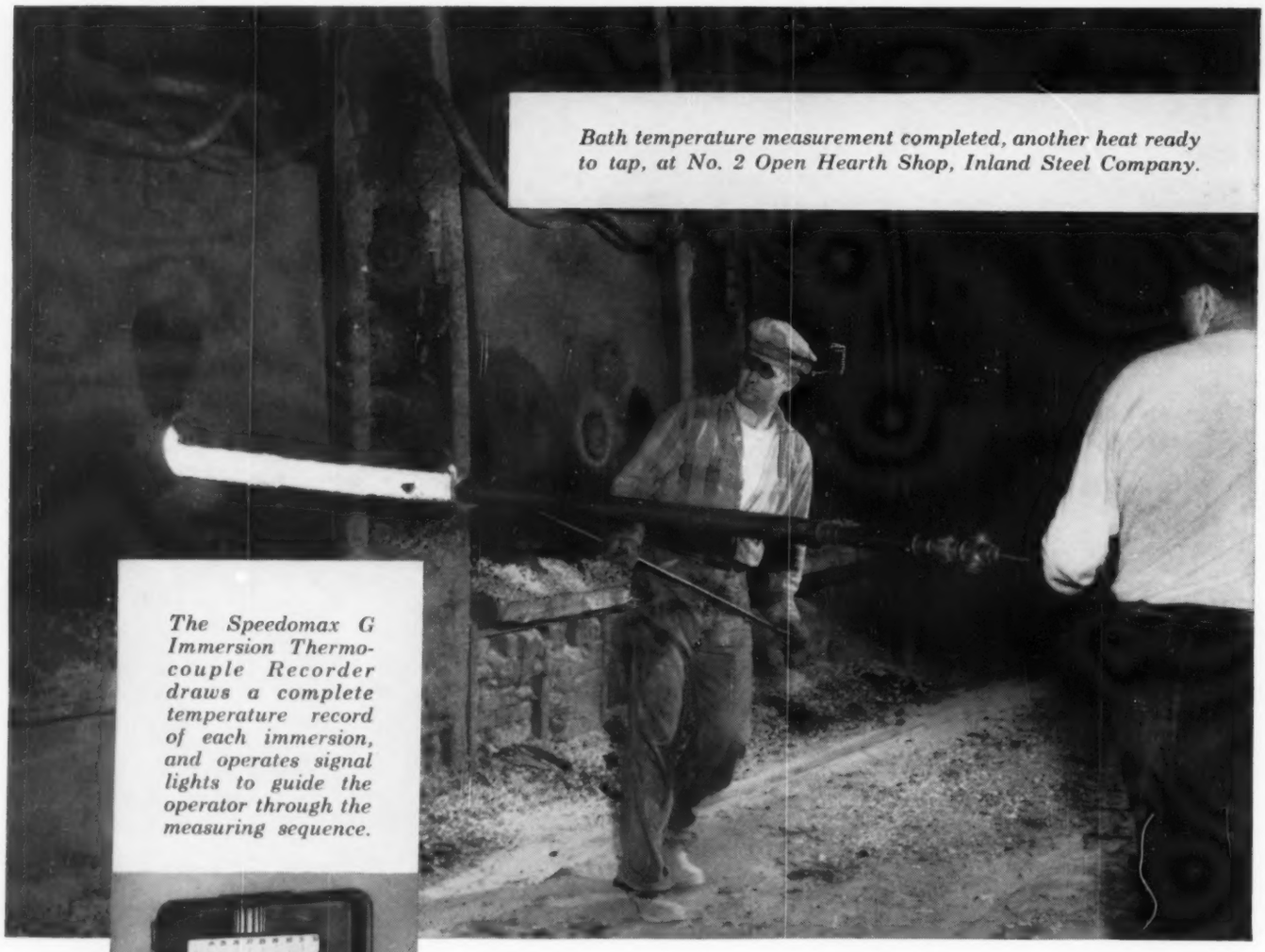
△ U. S. 2,803,534, issued Aug. 20, 1957 to Otwin Cuscoleca, Felix Grohs, Wolfgang Kuhnelt, and Kurt Rosner, assigned to Oesterreichisch-Alpine Montangesellschaft, describes a process for the production of high grade steels by refining carbon-containing iron baths with oxygen.

The inventors state that it is possible to produce in a converter a high grade steel not only having low phosphorus and nitrogen content, but also having an extremely low oxygen content, comparable to that of a good open hearth steel. This result is attained by directing oxygen from one or more nozzles of a carbon-containing iron bath in a restricted area to produce a limited reaction center having a maximum temperature on the surface of the bath, while regulating the supply of oxygen in such a manner that the consumption of oxygen per ton of metal does not greatly exceed the theoretical quantity of oxygen necessary.

The position of the oxygen lance 8 in the converter 1 is shown in Figure 4. As shown, it penetrates part way through the layer of slag 6, and impinges on a relatively small area of the surface of the iron bath, without substantial penetration of the bath.

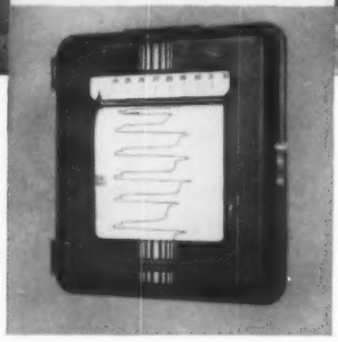
Figure 4





Bath temperature measurement completed, another heat ready to tap, at No. 2 Open Hearth Shop, Inland Steel Company.

The Speedomax G Immersion Thermocouple Recorder draws a complete temperature record of each immersion, and operates signal lights to guide the operator through the measuring sequence.



World's largest open-hearth shop completely equipped with L&N Immersion Thermocouples

Teamwork, enthusiasm, and detailed planning enable the operators of No. 2 Open Hearth Shop at the Indiana Harbor Works, Inland Steel Company, to break production records and increase its annual capacity consistently.

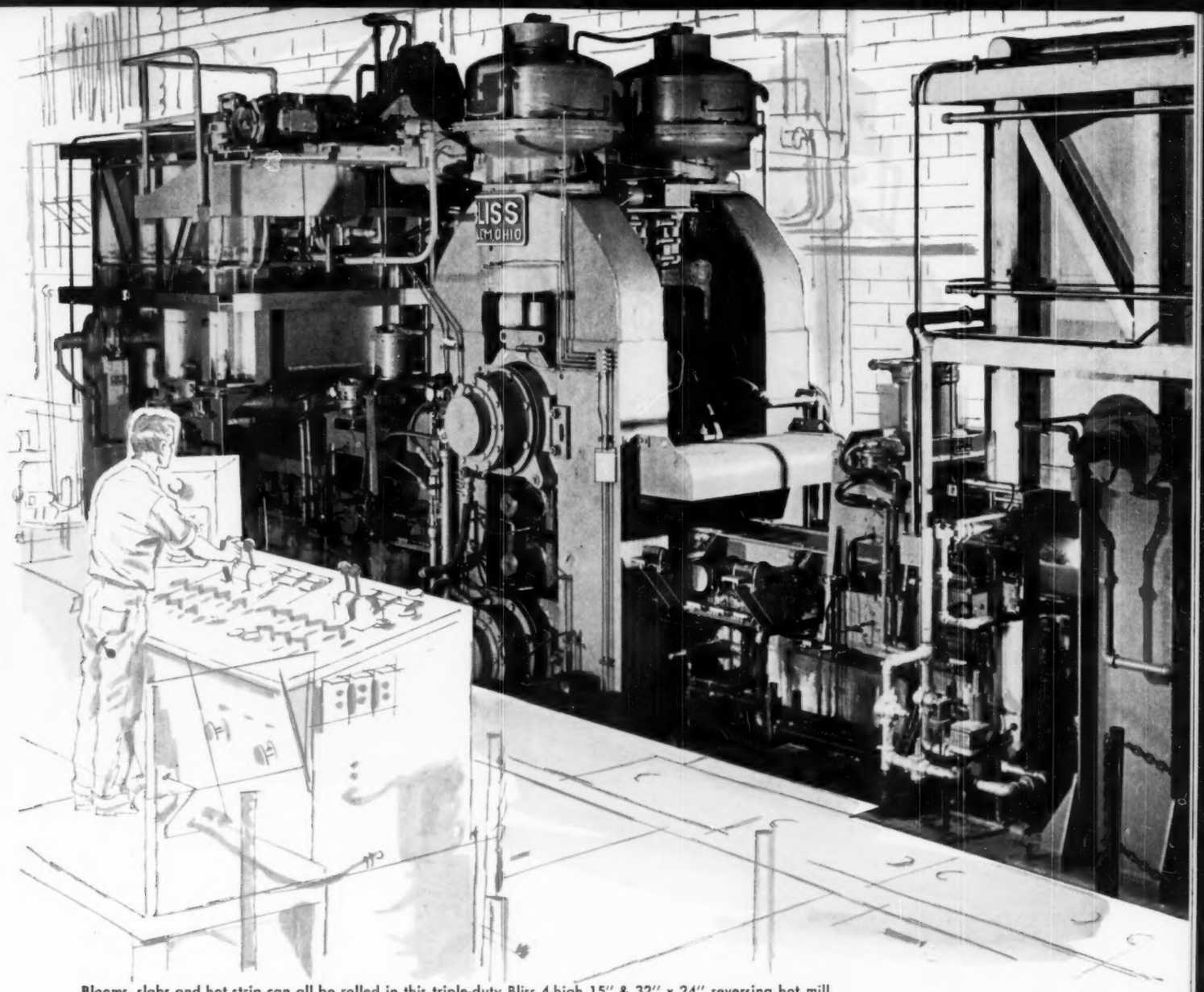
An important part of their long-range planning was completely equipping this 24-furnace shop—the largest in the world—with 60 Leeds & Northrup Immersion Thermocouples (44 on the floor, 16 on standby) and 12 Speedomax G recorders for bath temperature measurement.

Well aware of the advantages of "controlling" the heat and of tapping at proper temperature—reduction of skulls and scrap, reduced fuel cost, longer stool, mold, and ladle life, etc.—personnel at No. 2 welcome the reliability and ease of maintenance of the L&N equipment. Normally only the quartz tip has to be replaced after each immersion—a simple operation performed on the furnace floor—and the couple is back in service, with no "time out" for cooling required.

Averaging between 90 and 100 readings per day, No. 2 Shop keeps a meticulous record of the performance of each couple and the consumption of expendable parts. As a result, they compile precise figures on the cost per reading—and feel they're getting reliable, significant bath temperature data at minimum expense.

If you'd like full details about the L&N Immersion Thermocouple and Speedomax recorder, request Process Data Sheet 643(1) from our nearest office, or write us at 4942 Stenton Avenue, Philadelphia 44, Pa.

LEEDS NORTHRUP
Instruments Automatic Controls • Furnaces

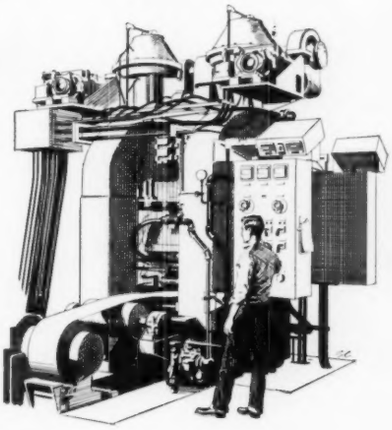


Blooms, slabs and hot strip can all be rolled in this triple-duty Bliss 4-high 15" & 32" x 24" reversing hot mill.

U-235 or magnetic alloys, it's all the same to these Bliss mills

Among the key installations with which the new Westinghouse Metals Plant at Blairsville, Pa., explores the unknown in metalworking are two unusual Bliss rolling mills. Blairsville's business is finding ways to cast, roll, forge and otherwise fabricate new and experimental metals. The materials rolled range from uranium alloys to magnetic materials so sensitive that the pressure of a finger will alter their electrical properties. The Bliss mills and handling equipment combine precision of control with the ability to stand extremely heavy rolling stresses. Large enough to provide limited production output, they can take an alloy from ingot down to 0.010" cold-rolled strip.

Whether your plans call for highly specialized mills like these or standard rolling and mill processing equipment, Bliss can help solve your problem. For more information, send for a free copy of our 60-page Rolling Mill Brochure, Catalog 40-A.



Hot rolled strip is further reduced to gages as thin as 0.010" in this Bliss 4-high 8" & 28" x 24" reversing cold mill.

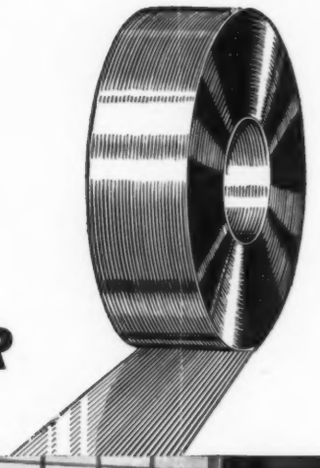
BLISS
SINCE 1857

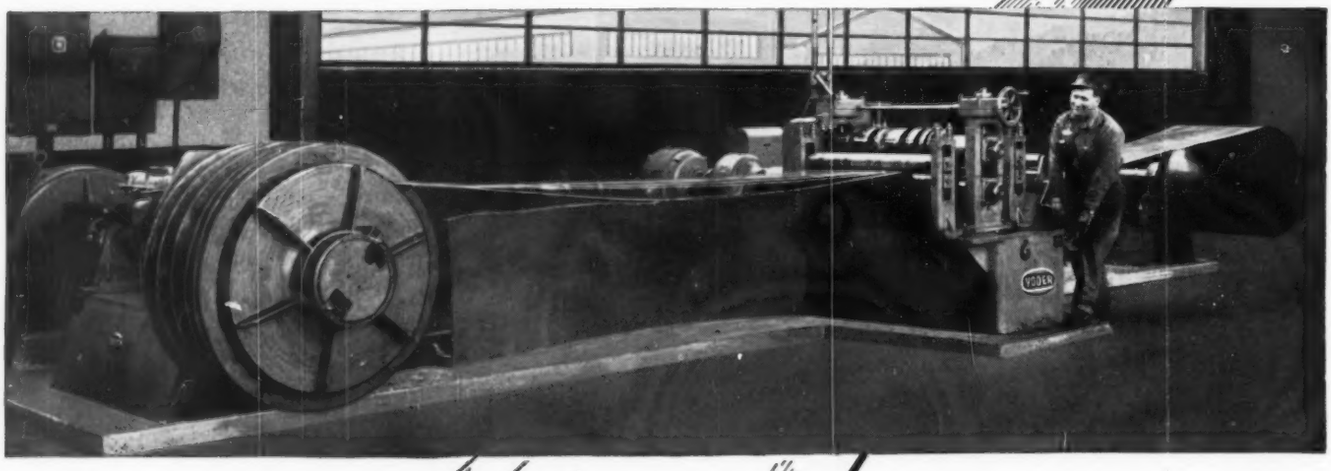
100 years of making metal work for mankind

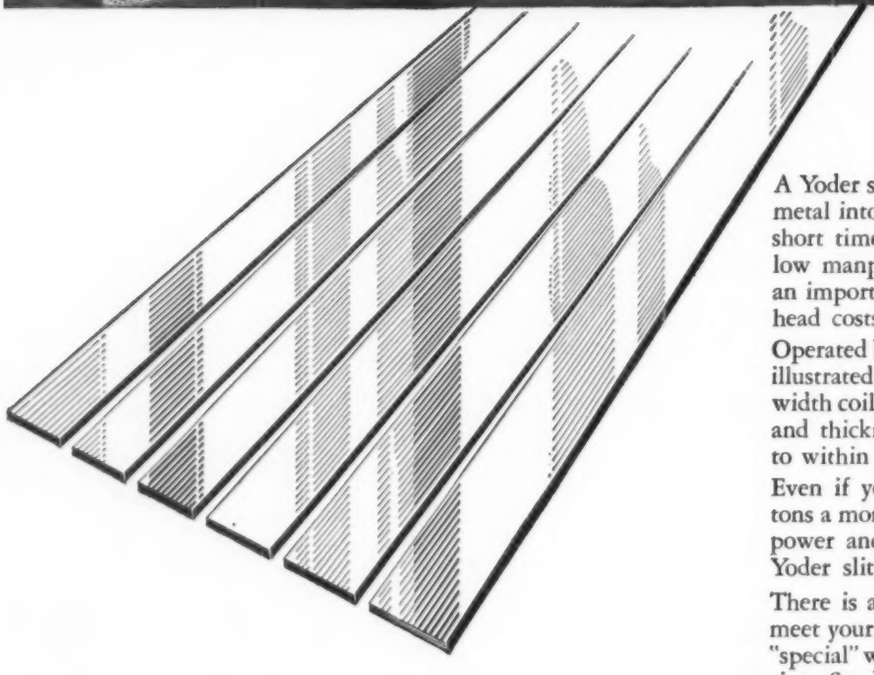
E. W. BLISS COMPANY, Rolling Mill Division, Salem, Ohio

Subsidiary: The Matteson Equipment Company, Inc., Poland, Ohio

from cold strip to slit strands
IN SECONDS...
with a YODER
ROTARY MULTIPLE SLITTER







A Yoder slitter converts mill-width coils of flat-rolled metal into many variable-width strands in amazingly short time. Speed, coupled with great accuracy and low manpower requirements, makes a Yoder slitter an important factor in keeping production and overhead costs down.

Operated by only two men, the Yoder Type 3-48 slitter illustrated is designed to accommodate standard mill-width coils up to 48 inches wide, in a variety of metals and thicknesses. The slit strand widths can be held to within a .004" tolerance.

Even if your steel requirements are as little as 100 tons a month, the savings to be realized in time, manpower and raw material costs alone will pay for a Yoder slitter in the first few months of operation.

There is a Yoder slitter designed and engineered to meet your requirements, and to speed the delivery of "special" width stock in a wide range of large or small sizes. Send for your free copy of the fully-illustrated, 76-page booklet, "Multiple Rotary Slitting Lines."

THE YODER COMPANY
5495 Walworth Avenue • Cleveland 2, Ohio

ENGINEERING **YODER** MANUFACTURING

ROTARY SLITTING LINES

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COLD ROLL FORMING MACHINES

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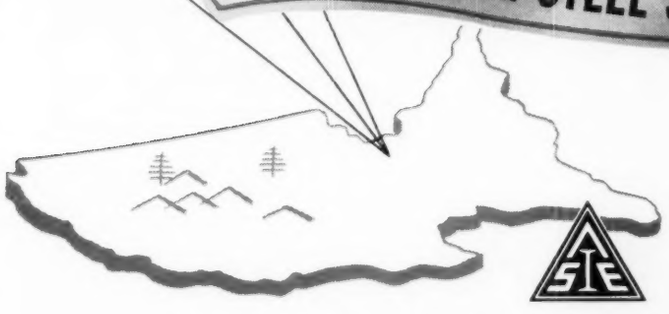
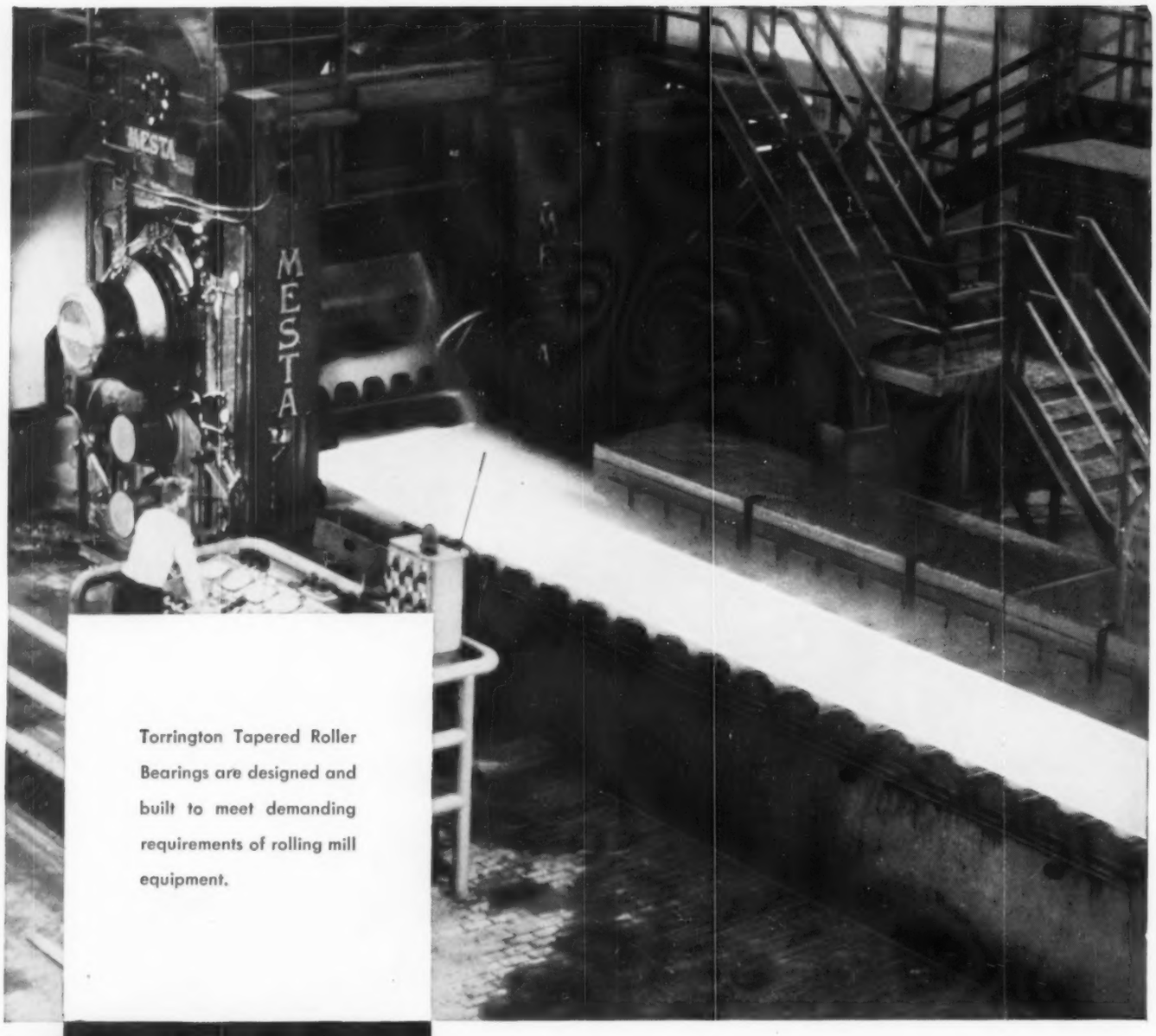
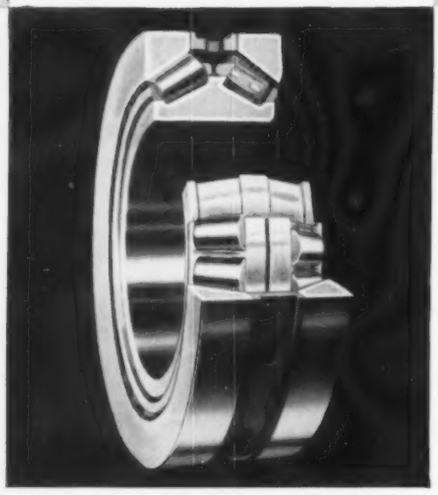


ASSOCIATION OF IRON AND STEEL ENGINEERS

1010 EMPIRE BUILDING • PITTSBURGH 22, PENNSYLVANIA



Torrington Tapered Roller Bearings are designed and built to meet demanding requirements of rolling mill equipment.



Meeting Production Demands!

Today's heavy production demands on modern continuous hot and cold strip mills put back-up roll thrust bearings to severe test.

That's why you find so many Torrington Two-Row Tapered Roller Bearings in this service throughout the country. Operators have learned that they can rely on Torrington Bearings to roll out record tonnages with only routine maintenance.

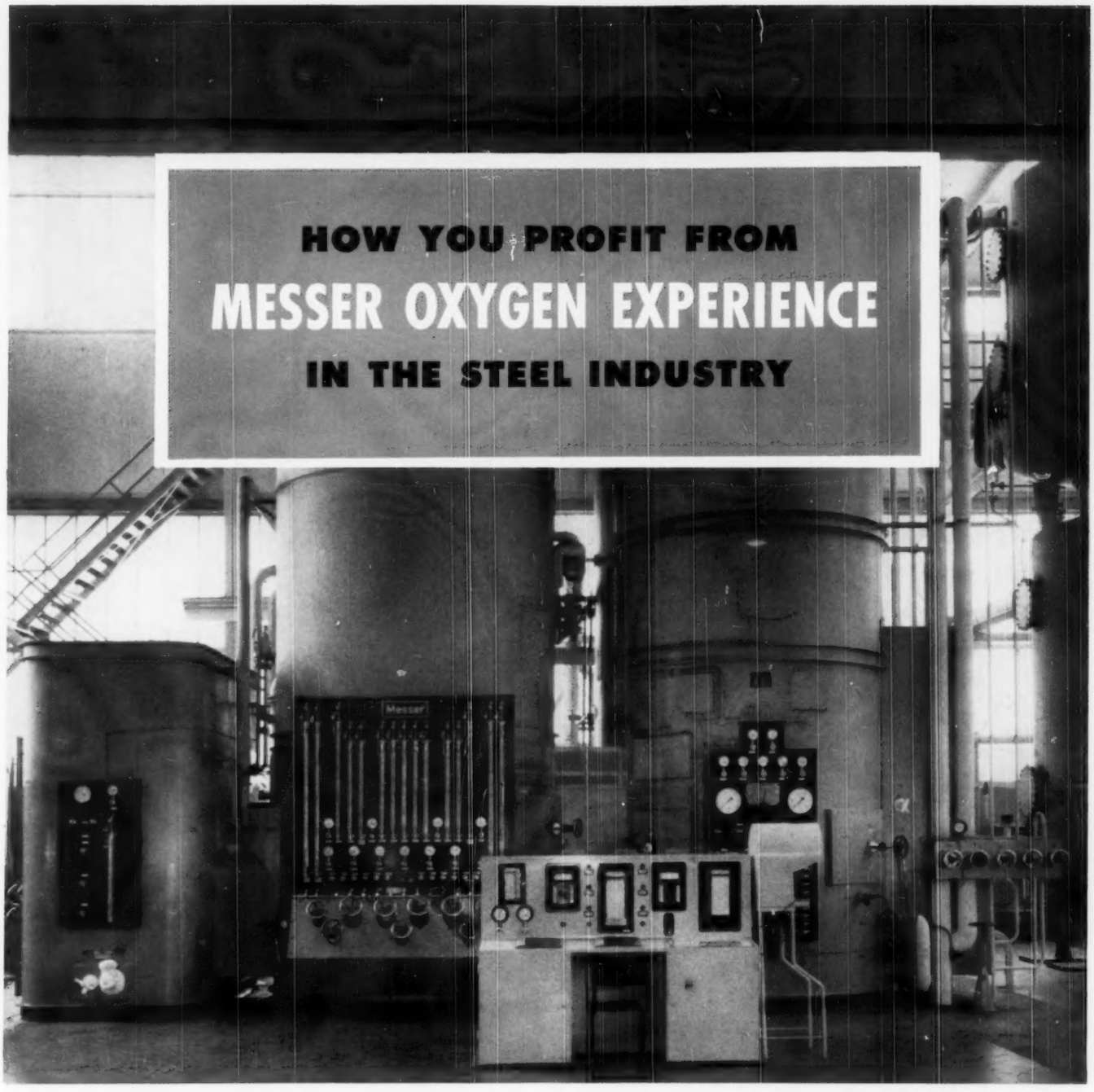
Little wonder—steep-angle design gives them capacity to spare for handling heavy thrust loads. Only highest quality electric furnace, alloy-bearing steel is used, carburized and heat-treated for toughness, hardness, stability and uniformity. Precision workmanship assures even load distribution and minimum friction.

Torrington Two-Row Tapered Roller Bearings are available with either pin-type or cast-bronze, land-riding cages. Like Torrington Four-Row Tapered Roller Bearings and Spherical Roller Bearings, they offer performance you can rely on when production schedules demand the best. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

TAPERED ROLLER • SPHERICAL ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST



In the steel industry, continuous operation is the key to efficient production. Messer's long and broad experience in the engineering of oxygen plants means dependable, month after month, production—and MONEY SAVED.

For example, here is a report from Cockrill-Ougre (Luxembourg) on Messer dependability:

(from a letter dated November 19, 1956)

"... We are confirming that the installation of a plant of 80 tons per day capacity, which you furnished, has been functioning at our facilities since February of 1954. After small adjustments during start-up, two periods of uninterrupted service of 12 and one-half months were obtained.

Gentlemen, we are most happy to express our distinct satisfaction."

In the United States and abroad, more than 1500 Messer Oxygen plants are performing efficiently and dependably. May we give you more information?

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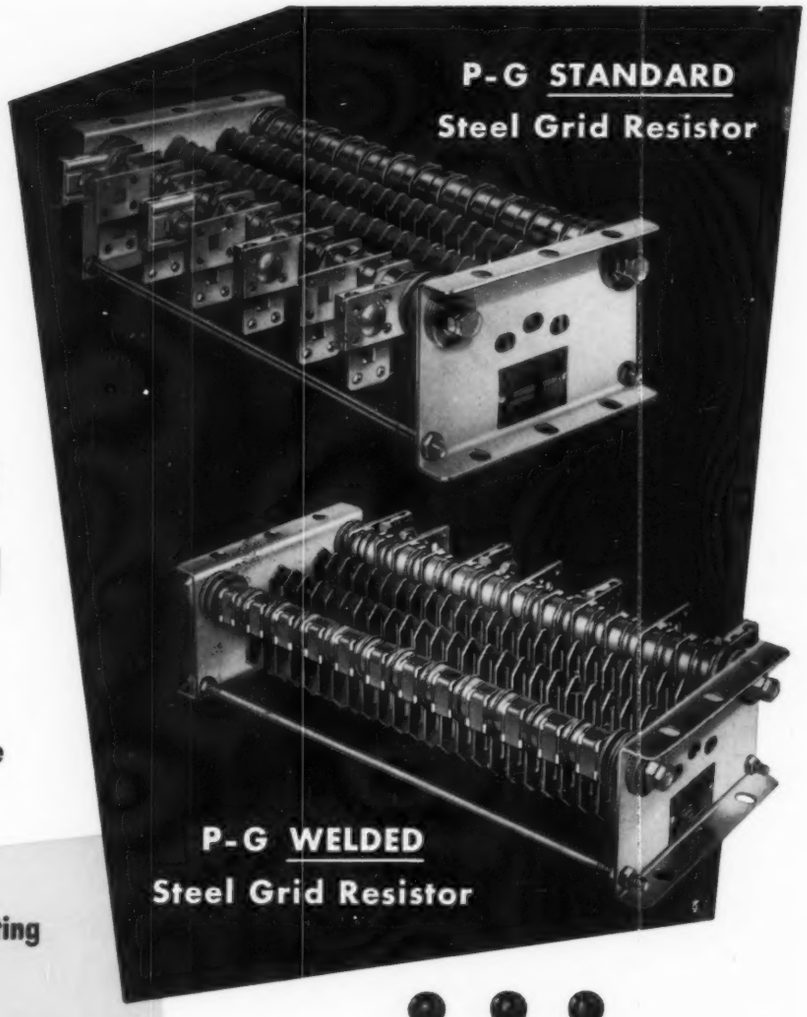
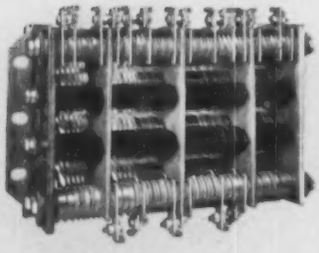
Built for severe service conditions
Protects vital electrical equipment
Constant "trouble free" performance
Quick adjustments easily made

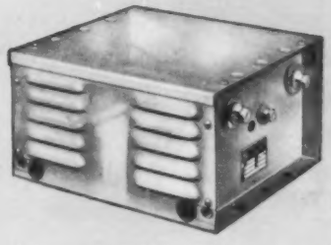


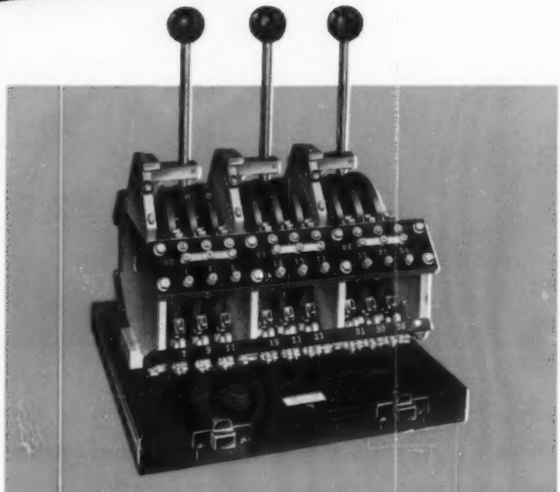
P-G Resistors for Internal Mounting in Face Plate Controllers



Standard Units for 2 to 25 H. P. Motors. Also supplied for external mounting.

P-G Resistors for
SAFETY LIMIT STOPS
Available in standard units for any size motor.





P-G Type MD **Master Switch**
for general application in Mill Service

Save valuable mounting space . . . One to four switches in a single enclosure . . . Overall length less than 22" on four-unit Switch.

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for Morgan Engineering cranes and mill equipment

New automation techniques put responsibility for precision manufacture of Morgan cranes and mill equipment in the hands of skilled technicians . . . plus exacting, efficient production facilities.

This 135-ton milling and boring machine, for example, handles giant weldments with new speed and ease . . . but maintains the extreme accuracy we demand for all components of Morgan-built equipment. An interesting feature is a television screen that lets the operator read vernier scales on a lower level without leaving the control platform.

Automatic submerged arc welding of girders . . . a 52-foot stress relieving furnace . . . the world's largest flame cutting facilities and other new production facilities contribute to the "extras" you get in today's Morgan-built products. Let our representative help *you* plan for more profitable, continuous-flow production with Morgan cranes and mill equipment.

THE
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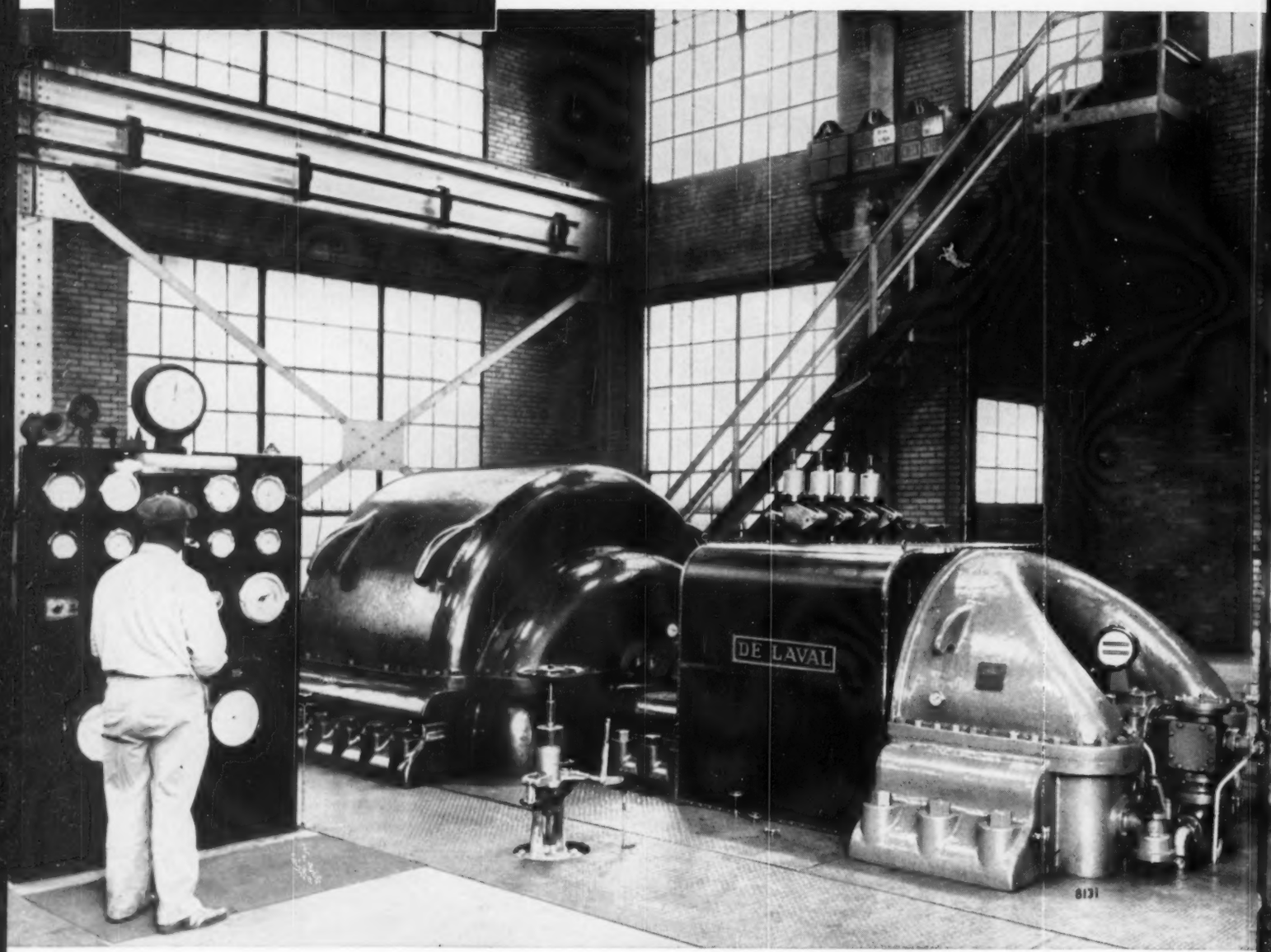
Overhead electric traveling cranes, gantry cranes, open hearth special cranes, plate mills, blooming mills, structural mills, shears, saws and auxiliary equipment.

DE LAVAL
BLAST FURNACE BLOWERS

give 20 years of service at Great Lakes Steel Corp.



Shown is one of two De Laval centrifugal blast furnace blowers at the Ecorse, Michigan, plant of the Great Lakes Steel Corporation, Division of National Steel Corporation. This 85,000 cfm unit was installed twenty years ago; another 75,000 cfm unit went on the line a year earlier. Both have given dependable round-the-clock service ever since. These turbine-driven blowers are hooked up to a multi-head which enables either one to be used in conjunction with any of the three blast furnaces.

De Laval centrifugal blowers are built in single and multi-stage types to supply air in volumes up to 150,000 cfm for all classes of service in steel, gas and coke plants. The wealth of application experience acquired by De Laval over the years assures a correct and economical solution to your blower problem.

Send for Bulletin 0504

DE LAVAL *Centrifugal Blowers*

DE LAVAL STEAM TURBINE COMPANY

870 Nottingham Way, Trenton 2, New Jersey

DL-381

Man with a chill

With light taps of his hammer, one of Mack-Hemp's skilled foundrymen coaxes a cast iron chill into place in the sand of a mold for a large steel mill roll. His concern for its exact position stems both from personal pride of workmanship and from the long tradition of painstaking precision which he is helping to maintain . . . a tradition that extends back over 150 years.

This combination of individual skill backed by long experience is the secret of Mackintosh-Hemphill quality; it's the prime reason why *you get more tonnage from the rolls with the striped red wabblers.*

MACKINTOSH-HEMPHILL
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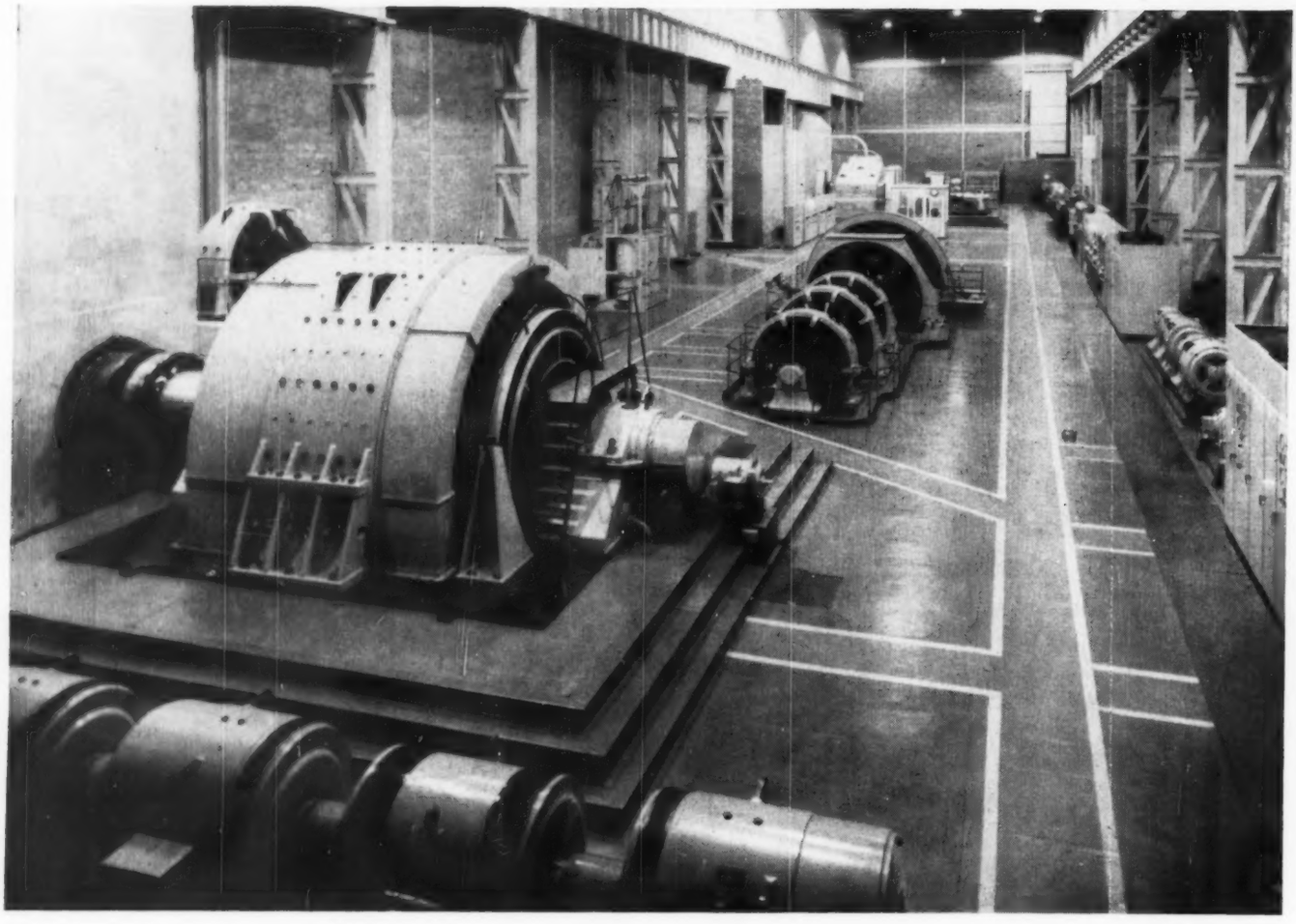

COMPLETE STEELWORKS ELECTRIFICATION

Complete projects are a specialty of English Electric. The typical example illustrated here shows the motor room of a modern steelworks. It contains a 7000 H.P. reversing plate mill drive with Ilgner set; a 1250 H.P. edger drive, scale breaker, and broadside mill drives of 1000, 1500 and 3500 H.P. These drives and the associated equipment were designed and built by English Electric.

If you are planning a complete steelworks electrification, or simply the addition for a small auxiliary drive, give us a call at any district office or write direct to our Metal Industries Division in St. Catharines or The English Electric Export and Trading Company Limited, Beaver Street, New York, N. Y. Our extensive experience is at your disposal.

'ENGLISH ELECTRIC' **DIRECT CURRENT DRIVES**

ENGLISH ELECTRIC COMPANY OF CANADA, LIMITED, ST. CATHARINES, ONT.
VANCOUVER, EDMONTON, CALGARY WINNIPEG, TORONTO, OTTAWA, MONTREAL AND HALIFAX

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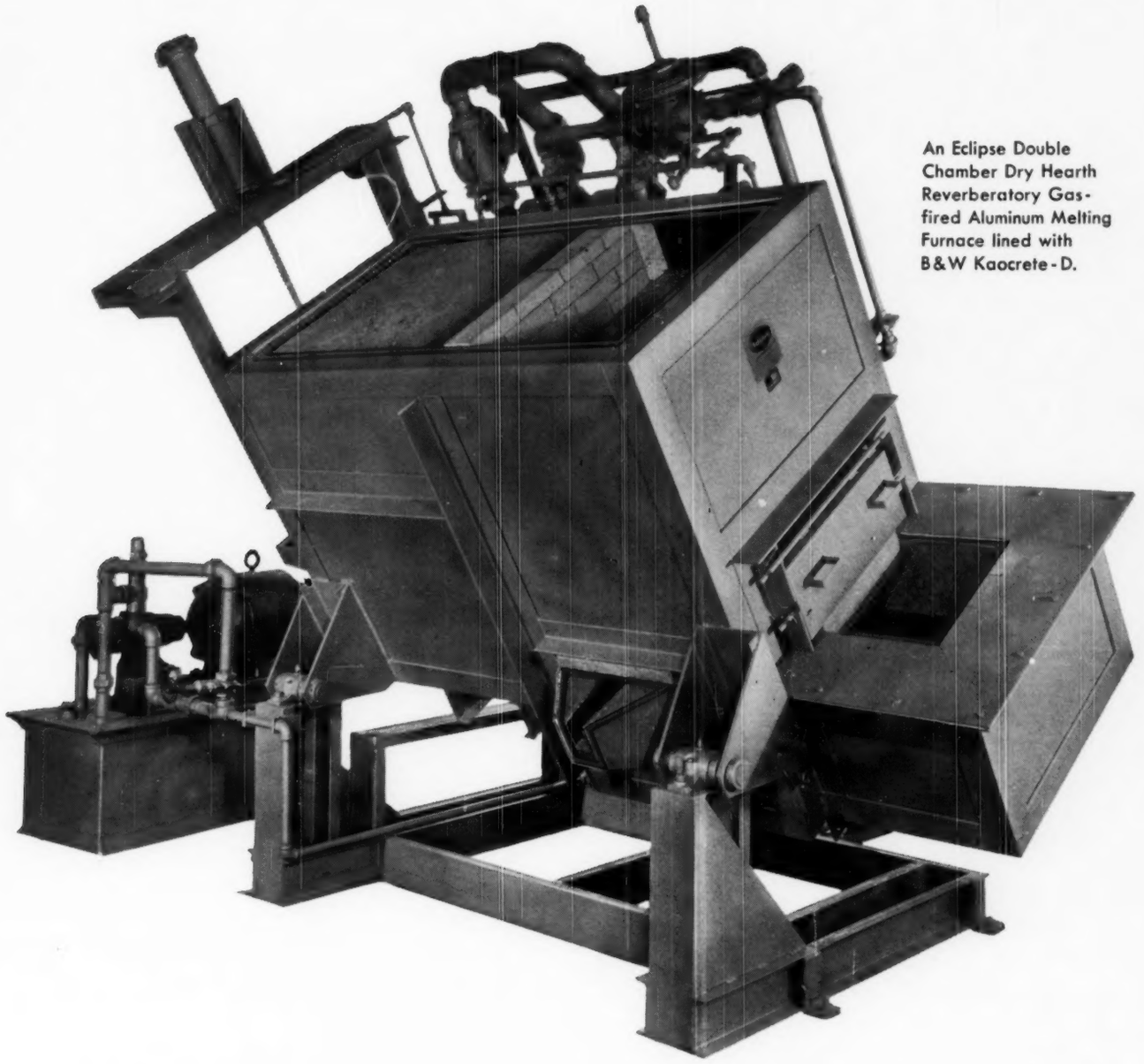

An Eclipse Double Chamber Dry Hearth Reverberatory Gas-fired Aluminum Melting Furnace lined with B&W Kaocrete-D.

Eclipse builds aluminum reverbs lined with B&W refractories

B&W Kaocrete-D provides a rugged refractory lining in this gas-fired aluminum melting furnace built by Eclipse Fuel Engineering Company of Rockford, Illinois. Equipped with an hydraulic tilting mechanism for pouring large sand castings or transferring molten metal to a holding furnace or large ladle, the furnace has separate melting and holding chambers lined with B&W Kaocrete-D.

Eclipse installs this B&W Refractory Castable in their aluminum reverbs because it provides three important benefits:

(1) The melting chamber is easy to clean since metal does not build up on or adhere to the face of B&W Kaocrete-D. That's because this refractory castable is non-wetting. Metal penetration of the contact face is kept at a minimum because of the low permeability of the castable. The refractory walls of the furnace do not require excessive scraping.

(2) B&W Kaocrete-D has unusually high strength. Combined with high density, this enables Kaocrete-D to withstand the abrasion of cleaning tools and the considerable physical abuse of charging.

(3) Kaocrete-D is easy to install. The refractory castable is simply poured and rodded in the furnace shell.

This is only one of the many applications of B&W Refractory Castables in a wide range of industrial furnaces. Why not investigate the advantages of these *specialized* refractories in your furnace designs?

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THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
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MAKE SURE YOUR NEXT BULK MATERIALS UNLOADER HAS THESE IMPORTANT DRAVO FEATURES:

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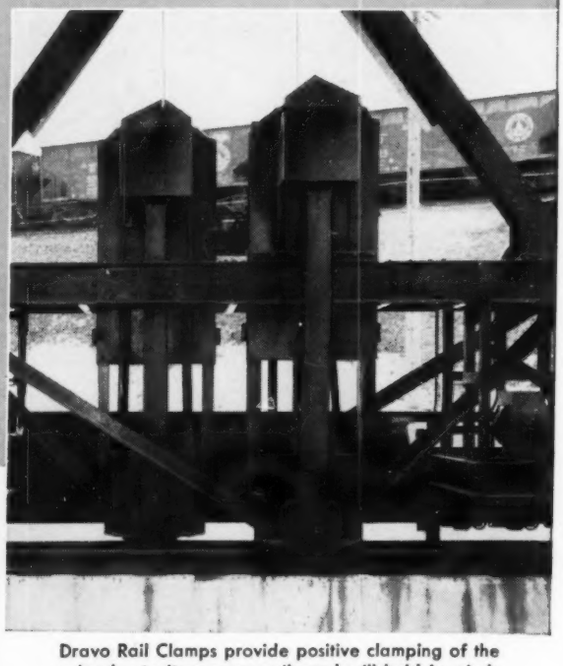
- Use of Unit Construction for Mechanical Elements

POSITIVE WIND PROTECTION WITH DRAVO RAIL CLAMPS



Dravo Rail Clamps provide positive clamping of the unloader to its runway rails and will hold in winds having velocities over 100 miles per hour. No adjustments necessary to keep clamps in working order.

DRAVO Automatic Rail Clamps

keep unloaders safe in winds above 100 mph

Dravo-designed Automatic Rail Clamps provide positive clamping and never need adjustment. Many other such features result from the fact that . . . Dravo bulk materials handling equipment is individually designed to handle each specific job economically, dependably and *safely.* Such performance is achieved by bringing together the customer's operating knowledge and the experience of Dravo's research, design and construction men.

This method has resulted in high efficiency unloaders and other bulk materials handling equipment that produce because they are tailored to fit the job. Dravo engineering features, built into every structure, provide for low maintenance and operating costs. For complete information on unloaders or ore bridges write to Dravo Corporation, Pittsburgh 25, Pa.

DRAVO
CORPORATION

Blast furnace blowers • boiler and power plants • bridge sub-structures • cab conditioners • docks and unloaders • dredging • fabricated piping foundations • gantry and floating cranes • gas and oil pumping stations • locks and dams • ore and coal bridges • process equipment • pumphouses and intakes • river sand and gravel • sintering plants • slopes, shafts, tunnels • space heaters • steel grating • towboats, barges, river transportation

SCHLOEMANN

This automatic, self-contained oil-hydraulic extrusion press for tubes and rods, power 700/780 tons, produces up to 60 light metal tubes per hour.

Self-contained oil-pump drive for automatic 700 ton vertical tubing and rodding press, and horizontal 1,650 ton press.

Vertical oil-hydraulic extrusion press for tubes and rods

Tubes, hollow sections and rods can be extruded in automatic operation by several methods.

Far-reaching automation permits a high rate of production.

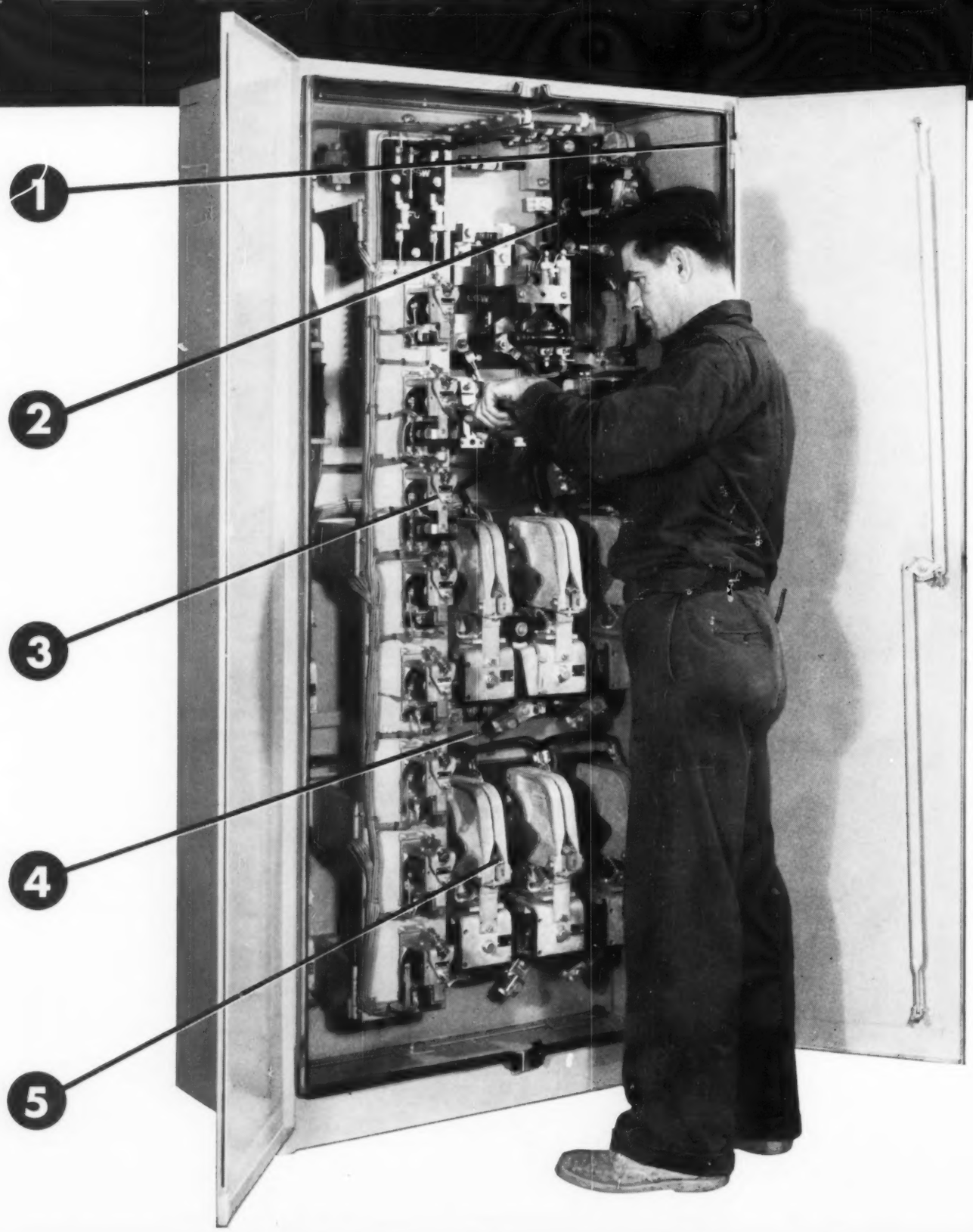
Automatically attained uniform extrusion speed results in a uniform quality of product.

Easily adjustable guides assure even wall-thickness of tubes; mandrels used for hollow sections can be easily adjusted and securely held in position to conform with the die opening.

FELLER ENGINEERING COMPANY
1159 Empire Building, Pittsburgh 22, Pa.
Exclusive U.S. Agent

ROLLING MILLS FOR FERROUS AND NON-FERROUS METALS • COUNTERBLOW HAMMERS • HYDRAULIC PRESSES

NEW



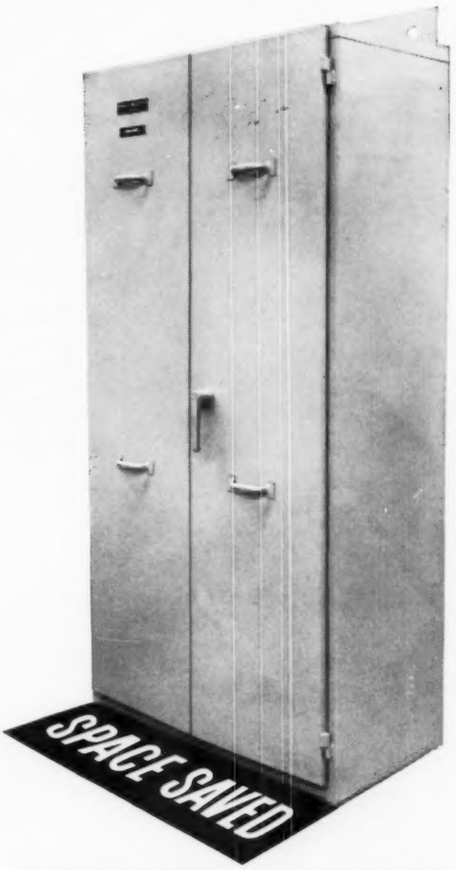
all front-connected d-c crane control from General Electric

SMALL SIZE AND ELIMINATION OF BACK AISLE CUT FLOOR SPACE REQUIREMENTS IN HALF!

General Electric announces the only completely front-connected d-c crane control panel on the market today! This new design feature eliminates any need for a back aisle. And here are five *more* reasons why General Electric is your best buy in d-c crane controls:

1. **Doors are quickly removed,** if desired, to provide ample room for installation and maintenance. The doors are hung on hinge pins to simplify removal. The lower pin is shorter than the top pin for ease of replacement.
2. **Devices are better protected** against shock and vibration by mounting on shock-resistant unit-bases. This construction also permits removal of devices as individual units from the front.
3. **Adjustable devices are readily accessible** because they are mounted on a hinged panel near the front of the enclosure. This panel swings open to provide access to a vertical wiring channel for the inter-connecting cables.
4. **Connections are made easy** by convenient terminals. Built-in wire troughs are formed by unit bases of individual devices.
5. **Spare parts are minimized** by use of rugged steel-mill devices, all of which use the same universal interlock for contacts on relays, and for auxiliary contacts on contactors.

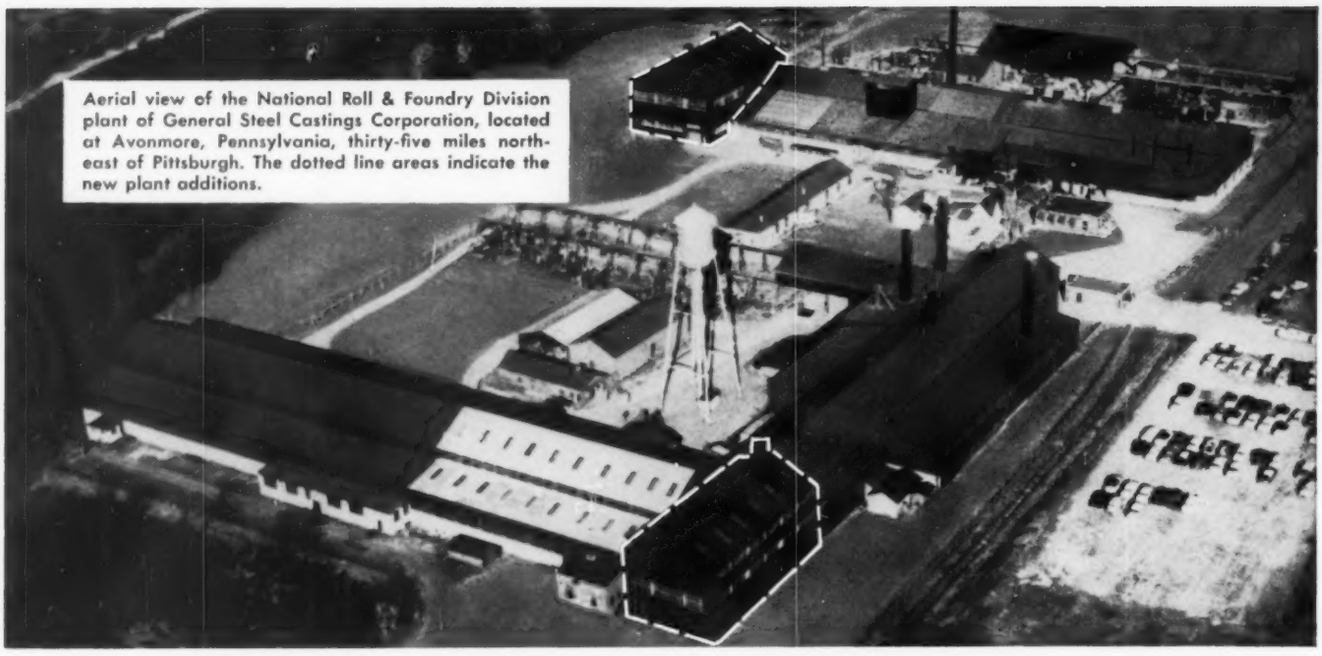
Take advantage of this new space-saving design now. ***Specify General Electric d-c crane controls!*** Ask your General Electric sales engineer for information on the outstanding performance characteristics of General Electric d-c crane control. Or write for GEA-6434, to Section 785-3, General Electric Company, Schenectady, New York. Industry Control Department, Roanoke, Virginia.



UP TO 50 PERCENT LESS FLOOR SPACE is required by eliminating the back aisle and the use of a smaller panel enclosure.

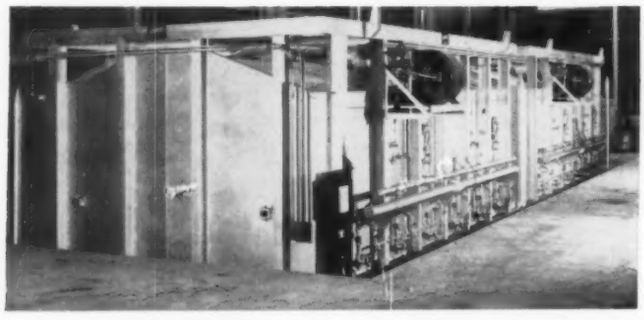
Progress Is Our Most Important Product

GENERAL ELECTRIC



Aerial view of the National Roll & Foundry Division plant of General Steel Castings Corporation, located at Avonmore, Pennsylvania, thirty-five miles northeast of Pittsburgh. The dotted line areas indicate the new plant additions.

GENERAL STEEL CASTINGS EXPANDS NATIONAL ROLL & FOUNDRY FACILITIES



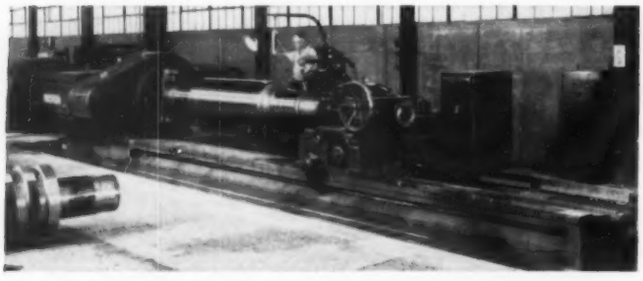
New annealing furnaces installed in the addition to the iron foundry. These furnaces are used in the heat treatment of alloy iron rolls.

To keep pace with the ever-growing steel industry, the National Roll Division's plant and equipment have been undergoing an expansion and modernization program that is nearing completion.

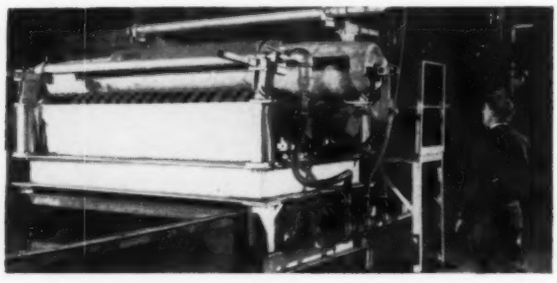
The photographs show four of these additions. There are many others: new pouring pits, furnaces, lathes and testing equipment, etc.

With these new facilities and National's almost half-a-century experience, we are prepared to furnish you the best in iron and steel rolls in a wide range of sizes and shapes for the most exacting rolling mill uses.

Specify National—you'll find they consistently live up to their reputation for long tonnage life, and quality of product.



A 60-inch precision-finish grinder, recently installed at National, is the "last word" in grinding equipment. This 60" grinder is one of the largest sizes manufactured for the roll industry.



Quenching machine designed and built by the National Roll & Foundry staff is used for rate control quenching of steel back-up rolls and steel work rolls.

GENERAL STEEL CASTINGS CORPORATION

NATIONAL ROLL & FOUNDRY DIVISION

Avonmore (Westmoreland County) Pennsylvania

General Steel Castings Corporation: General Offices, Granite City, Ill. • Plants: Granite City, Ill.—Eddystone, Pa.—Avonmore, Pa.

Simplify control problems...

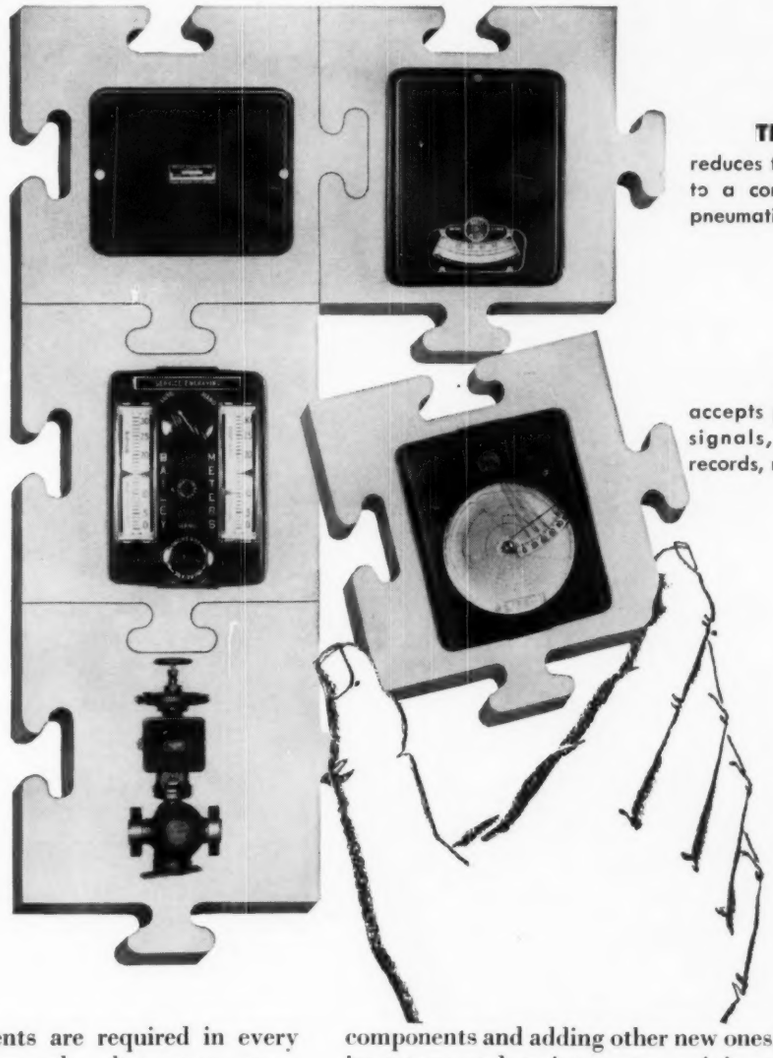
with the Bailey Building Block Method

Control problems are greatly simplified when you attack them using the Bailey Building Block Method. In a nutshell, the method consists of using standard components that fit together like building blocks. Virtually any control requirement can be handled by selecting standard components. Here are the parts you use and the functions they perform.

CONTROL RELAY
takes signals from the transmitter and computes corrective action in terms of pneumatic signals.

SELECTOR STATION
gives operator choice of hand or automatic control including set-point or bias adjustments.

POWER UNIT
is the "muscle" of the system. It performs whatever precise mechanical action is necessary to achieve control.



TRANSMITTER
reduces the measured variable to a common denominator, a pneumatic or electric signal.

RECEIVER
accepts pneumatic or electric signals, indicates and/or records, measurements.

Not all these components are required in every control system. You buy only what *your* system needs. When you change processes or add more automatic control, you can add additional standard components. Sometimes you may want to build a whole new system, re-using some of the existing components and adding other new ones. Spare parts inventory and maintenance training are reduced.

Hear the complete story of the Bailey Building Block System. Find how it can solve your control problems. See your Bailey Engineer or write for more information.

S10-1

BAILEY METER COMPANY
IRON AND STEEL DIV., 1047 IVANHOE ROAD, CLEVELAND 10, OHIO
In Canada — Bailey Meter Company Limited, Montreal

INSTRUMENTS AND CONTROLS FOR POWER AND PROCESS

BAILEY BUILDING BLOCK METHOD

for every wheel that turns in industry

Lubricating oils, cutting oils, multi-purpose greases, greases for spraying . . . whatever your needs, Atlantic has the lubricant to help you. Atlantic lubricants insure maximum lubricating performance at low cost for every job in the plant . . . for every wheel that turns in industry.

For lubricating products that fit your specific needs, or for expert assistance with your lubricating problems, write or wire any of these Atlantic offices.

Philadelphia
260 South Broad Street

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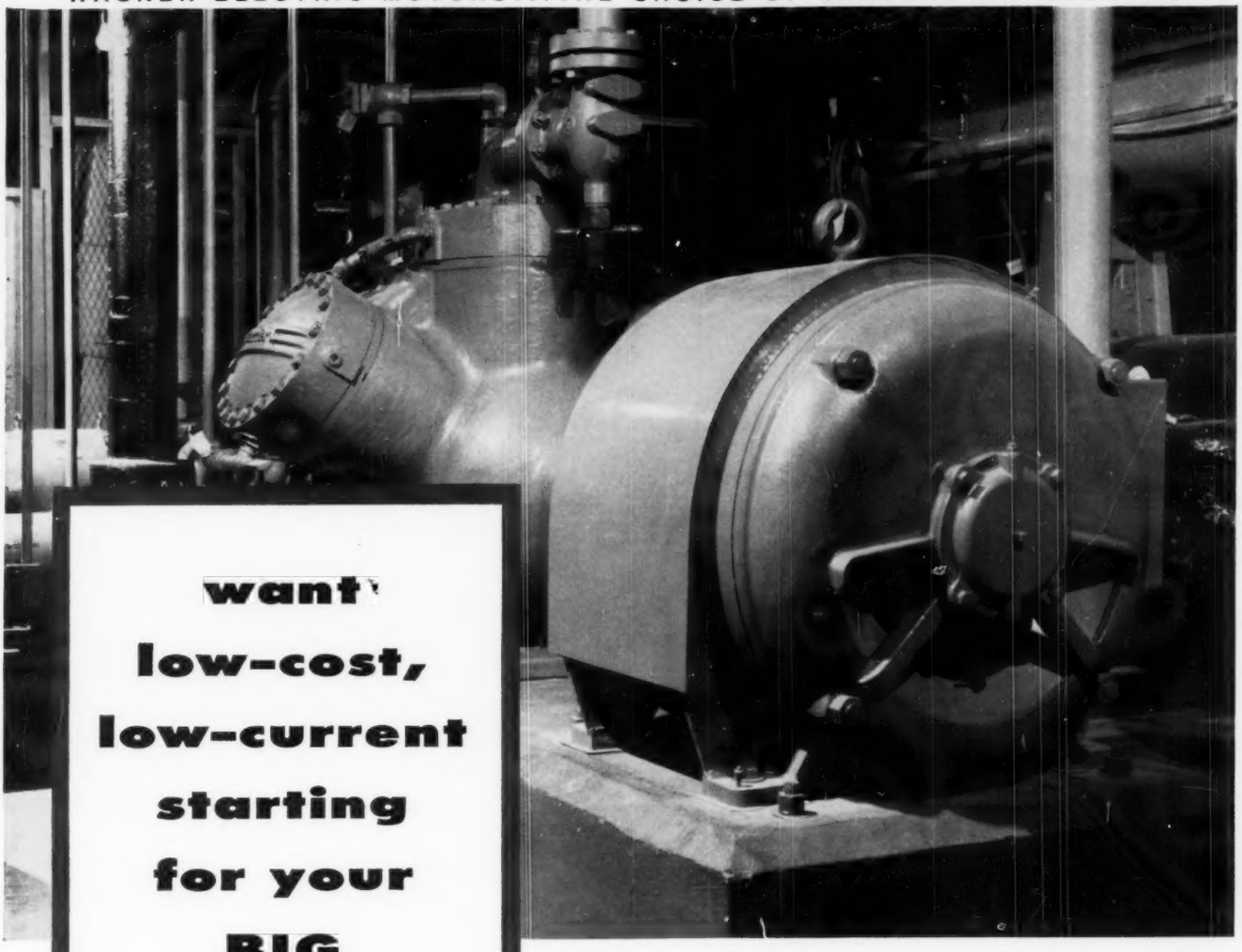
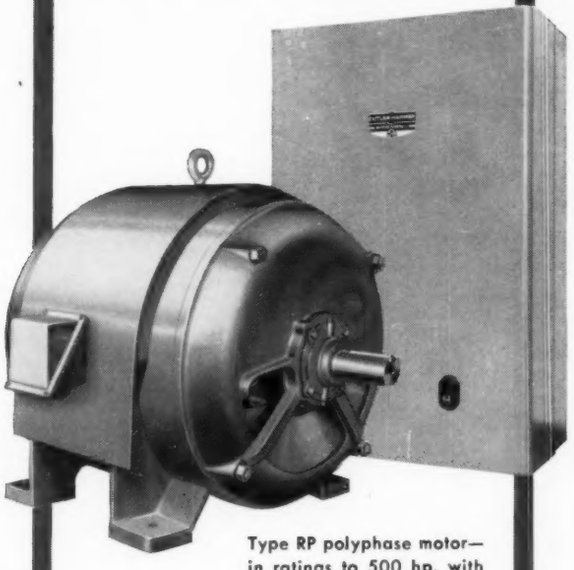
LUBRICANTS · WAXES
PROCESS PRODUCTS

WAGNER ELECTRIC MOTORS...THE CHOICE OF LEADERS IN INDUSTRY



want low-cost, low-current starting for your BIG MOTORS?



Type RP polyphase motor—in ratings to 500 hp. with increment type starter.

Specify Wagner Increment Motor-Starter Combinations

Part-winding starting is the simple, inexpensive way to limit the inrush of starting current in squirrel-cage motors up to 500 horsepower—and only the Wagner Increment Motor-Starter Combination gives you all these advantages:

LOW FIRST COST—Uses a standard Wagner Motor and a part-winding starter—no need for auto-transformers or resistors.

EASE OF INSTALLATION—Starter is compact and relatively light in weight, connections are simple and easy to make.

MINIMUM MAINTENANCE—The Wagner Motor requires only regular inspection, cleaning and lubrication—the starter needs very little attention.

APPROVED BY POWER COMPANIES—Meets all polyphase motor starting requirements of AEIC—EEI—NEMA—reduces voltage fluctuations—does not open the line during the starting period.

PROVED IN SERVICE—Wagner pioneered this Motor-Starter Combination—has been furnishing it for more than 18 years—its steadily increasing popularity is proof of its efficiency and dependability.

Why not take a look at Wagner Increment Motor-Starter Combination in operation? Ask your nearby Wagner Sales Engineer to show you an installation in your area. See how it works—judge for yourself, and let him help you select the combination that meets your requirements. Just call the nearest of our 32 branch offices, or write for Bulletins MU-128 and MU-195.

Wagner Electric Corporation
6483 Plymouth Ave., St. Louis 14, Mo., U.S.A.

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a leading name in steel plant equipment for over 75 years

This long record of superior service, and traditionally fine craftsmanship can be of real value if you are planning new operations or the expansion of existing facilities. Technical experience that has grown with the industries we serve, coupled with skilled workmen, will provide you with the greatest return on your investment dollar. If you have an engineering or special machinery problem, why not give PECOR a call?

This 40-page catalog tells the Pecor story in detail. Write for your free copy.

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PENNSYLVANIA ENGINEERING CORPORATION

NEW CASTLE, PA.

ENGINEERS • FABRICATORS

Blast Furnaces • Scrap Cars
Open Hearth Furnaces • Slag Cars
Oxygen Converters • Hot Metal Mixers
Ore Transfer Cars • Ladles • Jack Cars
Ladle Transfer Cars • Ingot Cars
Mixer Cars • Thermo Metal (Bottle) Cars

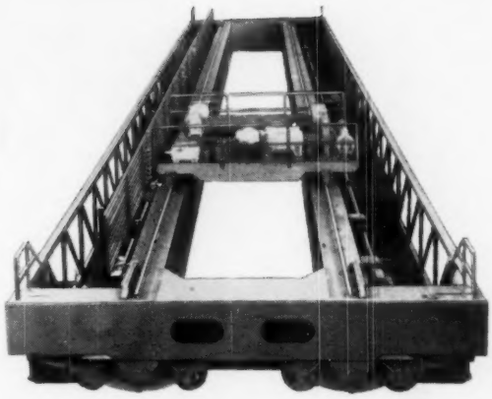
YOU NAME THE CRANE

"SHAW-BOX" WILL BUILD IT TO AISE SPECS OR YOUR OWN

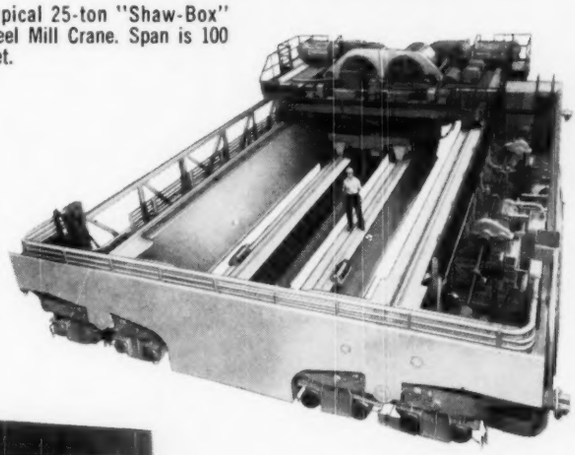
Ladle crane . . . plate or slab handling crane . . . trolley with worm-geared or spur-geared drive . . . soaking pit carriage — whatever your plans call for, "Shaw-Box" can be of service to you. In designing, engineering and building to AISE specifications or your own, we assure complete dependability and highest performance regardless of service conditions.

Mills everywhere have learned from experience that "Shaw-Box" know-how and vast production facilities save time, trouble and money. They know that "Shaw-Box" Cranes have many structural, mechanical and operational features that contribute to long-term satisfaction and economy.

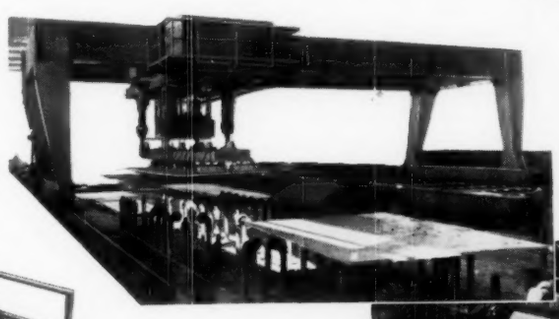
One of our engineers will gladly discuss your specific problem and tell you about our standard AISE designs for cranes of 15 to 200-ton capacity. Your inquiry is invited.



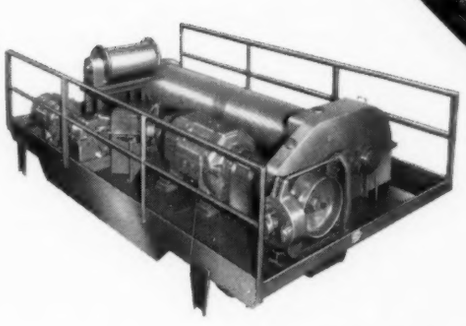
Typical 25-ton "Shaw-Box" Steel Mill Crane. Span is 100 feet.

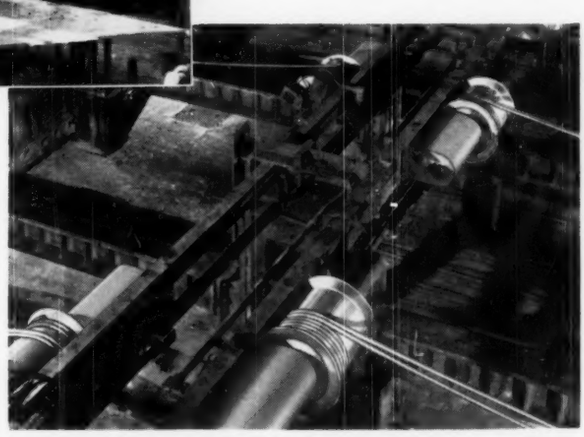


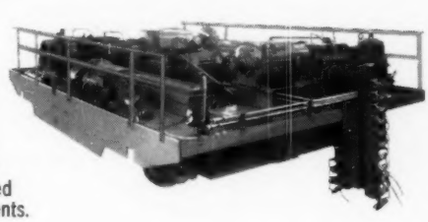
"Shaw-Box" Plate Handling Gantry equipped with lifting magnets.



This "Shaw-Box" Ladle Crane handles 200 tons of molten steel in a 90-ton ladle.







"Shaw-Box builds crane trolleys with spur-geared drive and with worm-geared drive. You can choose the type your experience has proved is most suitable for your requirements.

"Shaw-Box" Soaking Pit Carriages. The special "Shaw-Box" Spring Drive Cable Reels have automatic limit switches to cut off current when the carriages reach the end of travel in each direction.

57K-5

"Shaw-Box" ® CRANES

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

MANNING, MAXWELL & MOORE, INC.

SHAW-BOX CRANE & HOIST DIVISION

388 West Broadway • Muskegon, Michigan

Builders of "SHAW-BOX" and 'LOAD LIFTER' Cranes, 'BUDGIT' and 'LOAD LIFTER' Hoists and other lifting specialties. Other Divisions produce 'ASHCROFT' Gauges, 'HANCOCK' Valves, 'CONSOLIDATED' Safety and Relief Valves. 'AMERICAN' and 'AMERICAN-MICROSEN' Industrial Instruments, and Aircraft Products.

In Canada: *Manning, Maxwell & Moore of Canada, Ltd., Avenue Road, Galt, Ontario.*

THIS MAN CAN ADD TO YOUR PROFIT PICTURE. This is a Dowell service engineer—on the job. His knowledge and abilities in chemical cleaning can help you to greater profits. Recently, an eastern corporation used Dowell Service for its boiler cleaning maintenance. Dowell's service engineer studied the problem, did the job. His use of chemical solvents in cleaning tubes and other metal surfaces was effective. On the basis of Dowell Service, this company will realize improved profits of $440,000.

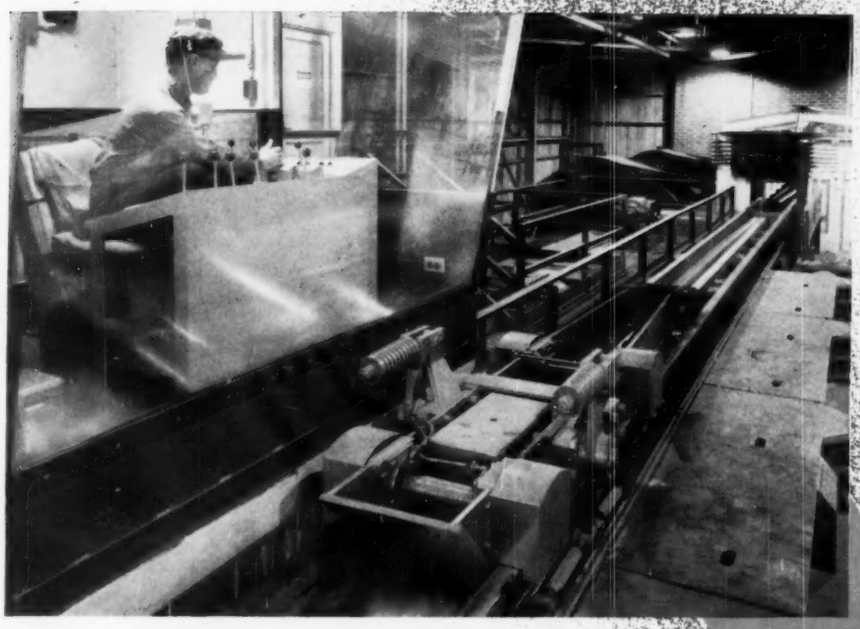
There are three ways you can clean your plant equipment: *Mechanically* with your own crews—inefficient, time consuming and expensive in today's industrial pace. *Chemically* with your own crews—again inefficient and unprofitable because of heavy payroll and the personnel's lack of qualification. Or with *Dowell Service*, the modern chemical cleaning method.

With Dowell Service you receive the benefits of more than fifteen years experience in chemical cleaning—plus special equipment, chemicals, research and trained personnel. You pay one charge, get an efficient job, handled by knowledgeable people.

Every industry can profit from Dowell Service. Ask your maintenance and operating engineers if they have thoroughly investigated the profit possibilities of using Dowell Service. DOWELL INCORPORATED—A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY. Headquarters and research center, Tulsa, Oklahoma; 165 offices and stations to serve you.

Chemical cleaning service for industry DOWELL

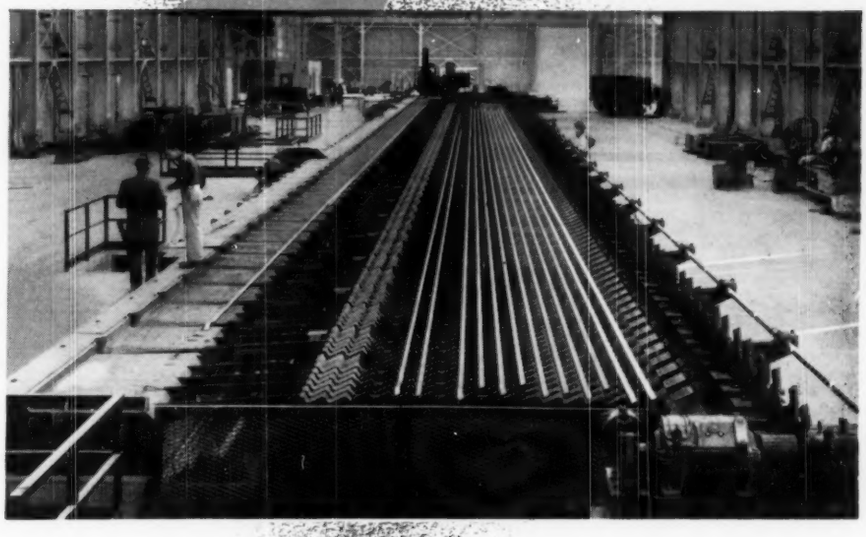
MORGAN MILLS
MORGAN QUALITY



MERCHANT AND ROD MILL
Atlantic Steel Company
Atlanta, Georgia

from START to FINISH

Morgan engineered and equipped from charging car to cooling bed this new Atlantic Steel Mill is now in full operation. This mill is just one of two hundred and twenty-one Morgan continuous rolling mills which have been purchased by steel plants throughout the world.



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MORGAN CONSTRUCTION CO., Worcester, Massachusetts

Rolling Mills • Morgoil Bearings • Wire Mills • Regenerative Furnace Control • Ejectors • Gas Producers

PENNSYLVANIA CUSTOM-BUILT THREE-PHASE POWER TRANSFORMER

Significant savings in installation costs resulted from the upright, one-piece shipment of this large three-phase, main step-up generating station transformer. Such handling was possible because of Pennsylvania's Contour Design, which permitted the manufacture of a unit so compact that only bushings and coolers were removed for shipment.

Designed and manufactured by Pennsylvania for a midwestern utility, the transformer will step up a generated voltage of 15,000 volts to a transmission voltage of 141,000 volts. Two low voltage sections of 15,000 volts are rated at 130,000 kva each. A duplicate unit, for delivery in 1958, has been ordered. Pennsylvania Transformer Division, McGraw-Edison Co., Canonsburg, Pa.

.. by the PIONEER of 1-piece, upright shipment of large power transformers

PENNSYLVANIA POWER TRANSFORMERS

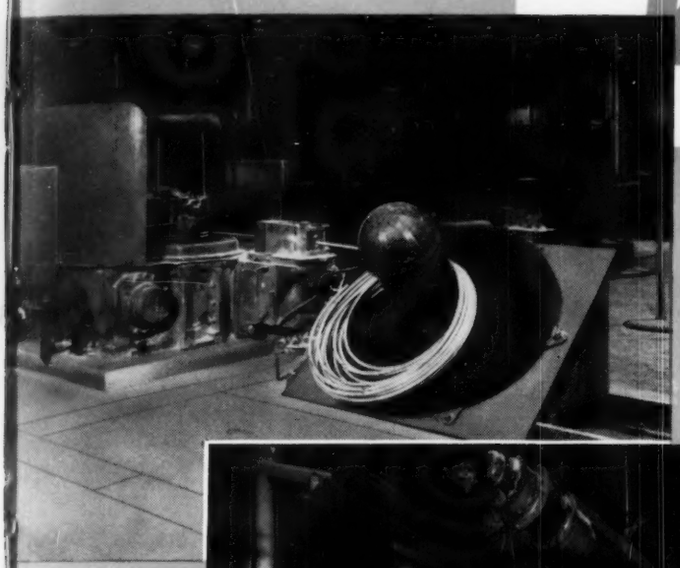
A TIP FOR THE TIMES

SPEED HEAVY WIRE PRODUCTION

with ADVANCED

Vaughn®

AUXILIARY EQUIPMENT



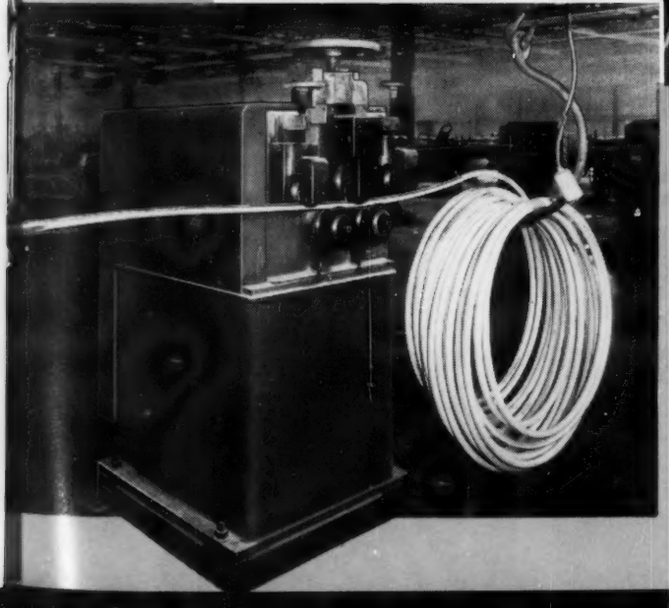
new FLOOR REEL

with Positioning Base

Meeting today's need for better pre-drawing preparation and handling of heavy wire, Vaughn presents this new Floor Reel upon which the coil is lowered, with Positioning Base. This advanced equipment permits the straightened, pointed wire end to be passed through die to grip with small effort by the operator—and better production!

new *Extra-Heavy* 4-ROLL CONTINUOUS POINTER

This king-size pointer is capable of accommodating a range of wire from ½" to 1¼". It has two vertical and two horizontal rolls for ease of pointing without twisting the wire, and is in every way a heavy, rugged, long-life machine for the most arduous service.



new ROLL STRAIGHTENER

At the beginning of the pre-drawing preparation cycle is the new Vaughn 3-roll straightener, where a section of the trolley-transported wire coil is mechanically straightened. This makes handling to pointer and die box an easy matter, contributing to the time and manpower savings that help boost production with modern Vaughn equipment. Details? Gladly, on request.

The Vaughn MACHINERY COMPANY

Cuyahoga Falls, Ohio, U.S.A.

COMPLETE COLD DRAWING EQUIPMENT—Continuous or Single Hole . . . for the Largest Bars and Tubes . . . for the Smallest Wire . . . Ferrous, Non-Ferrous Materials or their Alloys.

*Magnified (10 times) surface of steel sheet descaled with Wheelabrator Steel Shot

Over 100 installations have proved that the Wheelabrator mechanical descaling process is cheaper, more efficient, and provides a clean material that produces an improved end product.

Wheelabrator descaling uses no acids or pickle liquors. It removes scale by means of a metallic abrasive blast from one or more rotating wheels. Each wheel hurls abrasive in a fan-shaped pattern against the surface of the material being cleaned.

The resultant matte finish produced by this bombardment consists of minute cups on the surface of the cleaned metal. These cups serve to retain lubricants and drawing compounds, facilitating cold drawing and cold forming. This minutely roughened surface also provides a better bonding surface for coatings.

Cost Savings

1. Reduces or Replaces Acid Pickling
2. Reduces Acid, Acid Disposal
3. Generally Reduces Manhour Needs
4. Reduces Virgin Metal Loss
5. Requires Less Floor Space Than Pickling
6. Reduces Need for Scale Breaking
7. Lowers Cleaning Costs

Improved Workability

1. Better Finishes for Cold Rolling
2. Excellent Surface for Cold Drawing
3. Better Surface for Deep Drawing
4. Improved Surface for Cold Forming
5. Better Adherence of Finishes

Write today for this informative booklet on Wheelabrator applications in the mechanical cleaning of steel.

WHEELABRATOR
CORPORATION
396 S. Byrkit St. Mishawaka, Indiana

Forged hardened rolls to your exact specifications

Things are always busy in the shop where Bethlehem forged rolls are inspected and readied for shipment.

On any given day you're apt to see dozens of gleaming new rolls waiting side by side for their final okay. Often they're of assorted sizes and shapes, with no two alike. Near a 20-ton giant you may spot a midget weighing less than a hundred pounds. Some are long and lean with streamlined contours, and others are short, thick, and stubby.

No matter what your requirements in forged hardened rolls, Bethlehem can fill them. When you place an order with us, you can do so with complete confidence; your specifications on size, shape, hardness, and finish will be met in full. Moreover, you can count on good deliveries. Call us whenever you need rolls for cold-rolling ferrous sheets and strip . . . running-down and finishing operations on copper and brass sheets . . . hot- and cold-rolling aluminum sheets . . . cold-rolling aluminum foil.

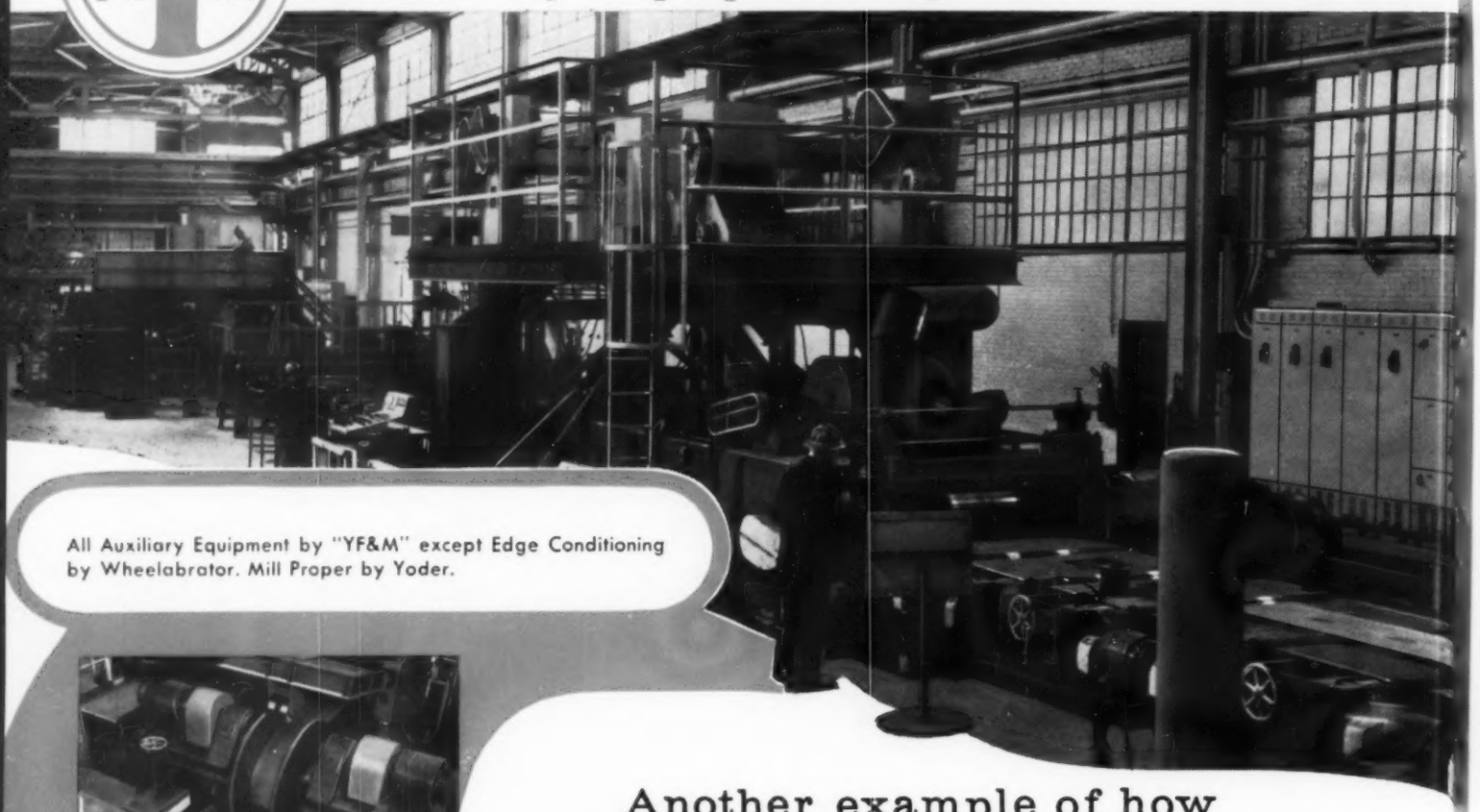
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

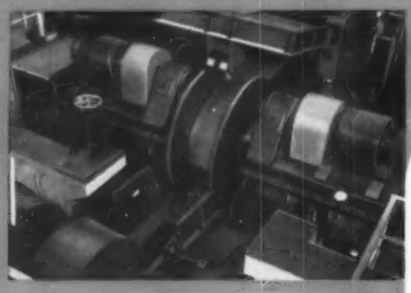
BETHLEHEM STEEL

BETHLEHEM STEEL

auxiliary equipment *for* ELECTRIC WELD PIPE MILL



All Auxiliary Equipment by "YF&M" except Edge Conditioning by Wheelabrator. Mill Proper by Yoder.



Only 20 seconds required to enter 30,000#, .500" thick x 54" wide Coils from Conveyor into Leveller, using this rugged Cone Type Uncoiler equipped with hydraulically operated Peeler and Coil Opener.

Heavy duty Up-Cut Shear equipped with Fawick Air-Flex Clutch. Shear travels hydraulically and automatically cuts at speeds of 45—180 FPM.

Over Hung Mandrel Type Side Trimmer equipped with eccentric sleeves on both top and bottom arbors to insure best possible edge for welding operation and longer knife life.

Another example of how

"YOUNGSTOWN"

serves the steel industry

This modern mill utilizes "YF&M" Auxiliary Equipment to produce 4½"—16" Dia. Electric Weld Pipe. Material: Hot Rolled Skelp Steel; width: 15"—54"; thickness: .125"—.500"; coil weight: 30,000#; line speed: 45—180 FPM. Advanced design and rugged construction for highest efficiency are features of this mill and its precision equipment.

YOUNGSTOWN Auxiliary Equipment built for this new Pipe Mill

- CONE TYPE UNCOILER
- COIL PEELER
- 7-ROLL ROLLER BEARING LEVELLER
- TRAVELING UP-CUT SHEAR
- SIDE TRIMMER
- SCRAP CHOPPER
- PINCH ROLL STANDS
- TABLES WITH SIDE GUIDES

Whatever your needs we'll be glad to quote, or discuss your problems

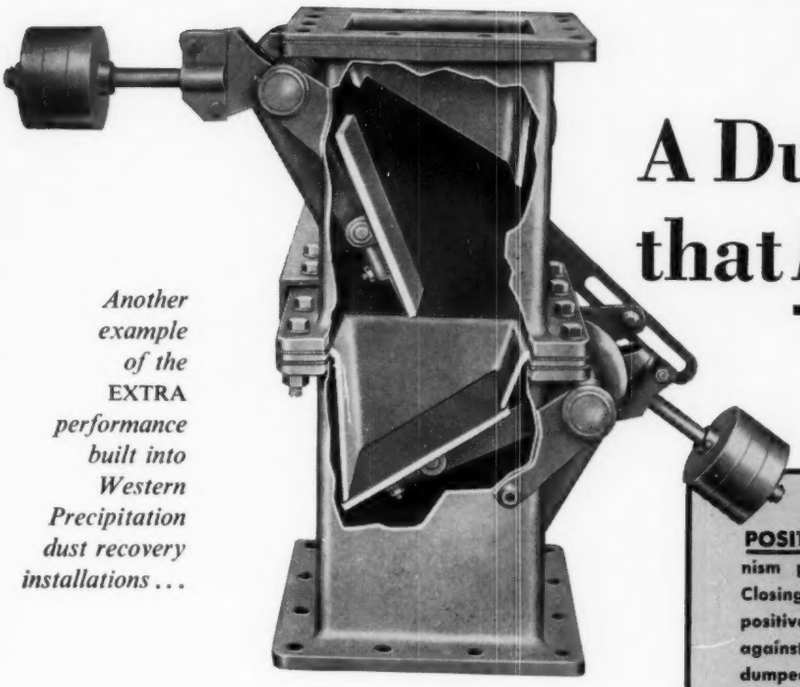
The Youngstown Foundry & Machine Co.

SERVING INDUSTRY SINCE 1885

Youngstown 1, Ohio

HEAVY MACHINERY • AUXILIARIES • CASTINGS • ROLLS

"YF&M" builds the best of them



Another example of the EXTRA *performance built into Western Precipitation dust recovery installations . . .*

A Dumping Valve that *Really Works**

No dust recovery installation is better than the valves controlling the dust flow out of the collection hopper – particularly in Sintering Plants where the system operates under substantial vacuum. Poorly-designed valves allow recovered dust to blow back into the system . . . cause troublesome draft losses . . . air infiltration . . . and cut down efficiency of even the best recovery systems.

But – typical of the extra care Western Precipitation puts into *every* recovery installation – is the *Western Precipitation R-1 Dust Valve* . . . an automatic dust valve that is unsurpassed for trouble-free operation and maximum working efficiency. Check the features at right and you'll see why . . .

POSITIVE ACTION: Electric motor-driven mechanism provides positive opening on time-cycle basis. Closing is by gravity – and is adjustable. Thus, valve positively opens even with lightweight materials or against high vacuum . . . closes only after material is dumped.

DOUBLE-FLAP SEALS: Two flaps open and close alternately on a positive cycle to insure continuous clean-out without allowing pressure surges into hopper.

GRAVITY FLUSHING: Gravity safety trip permits each flap seal to open automatically if overloaded, allowing flush-out of excess material. Valves then return automatically to time-cycle operation.

RUGGEDLY BUILT: All parts and seals are designed for heavy-duty service with minimum maintenance. Bearings are sealed against dust – are outboard-mounted to protect against heat and dust. Valve seats and flap seals are easily replaced. Motor is fully sealed and protected.

There are many other unique features your Western Precipitation representative will gladly explain. Or write direct!

The R-1 Valve is typical of the care that goes into every Western Precipitation product. Furthermore, no other organization – domestic or foreign – has had as many years of experience in all phases of recovery methods . . . *electrical* (COTTRELL), *mechanical* (MULTICLONE), *combination* electrical-mechanical (CMP) and *filter* (DUALAIRE). You get an experienced—*and unbiased*—recommendation from Western Precipitation.

* To date 15 steel companies have installed R-1 Valves . . . and every company has re-ordered additional installations!

COTTRELL Electrical Precipitators
MULTICLONE Mechanical Collectors
CMP Combination Units
DUALAIRE Reverse-Jet Filters
HOLO-FLITE Processors

Western Precipitation Corporation

Designers and Manufacturers of Equipment for Collection of Suspended Material from Gases . . . and Equipment for the Process Industries

Main Offices: **1067 WEST NINTH STREET, LOS ANGELES 15, CALIFORNIA**

Chrysler Building, New York 17 • 1 North La Salle Street Building, Chicago 2 • Oliver Building, Pittsburgh 22 • 3252 Peachtree Road N. E., Atlanta 5 • Hobart Building, San Francisco 4

Precipitation Company of Canada Ltd., Dominion Square Building, Montreal

Representatives in all principal cities

Great Names in Steel Making #VIII

OSCAR L. MAAG, *recipient of the ASLE National Award in 1956, was preeminently a lubrication engineer. Yet every mill in America that operates on roller bearings testifies to Oscar Maag's contribution to modern steel making.*

As sometimes happens in the initial trial of a new process or material, the first test of roller bearings in a rolling mill was quite successful. But as soon as increased speed and pressure were attempted, in a second installation, serious trouble developed.

The big Timken bearings (they measured 30"x16" in diameter) were taken back to the company's plant at Canton, Ohio, where they were lapped and studied on the test stand. The cause of failure was in the calcium soap grease used to lubricate the bearings. Furthermore, it was evident that no type of lubricant then available was capable of handling the load.

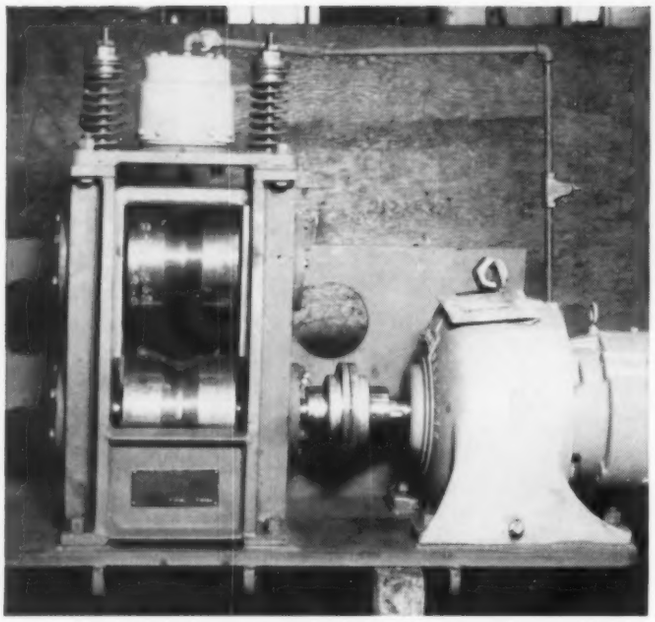
At that critical moment Oscar Maag, Timken's lubrication specialist, had an inspiration. Experimentally, he added sulphur chlorinated base cutting oil to the grease.

It was the first E. P. (extreme pressure) lubricant applied to rolling mill bearings, and it worked perfectly. Not only did it solve the immediate problem—it cleared the way for development of roller bearing mills in which speeds exceeding a mile-a-minute and pressures to 25,000 psi are successfully handled by today's Ironsides "E.P." lubricants.

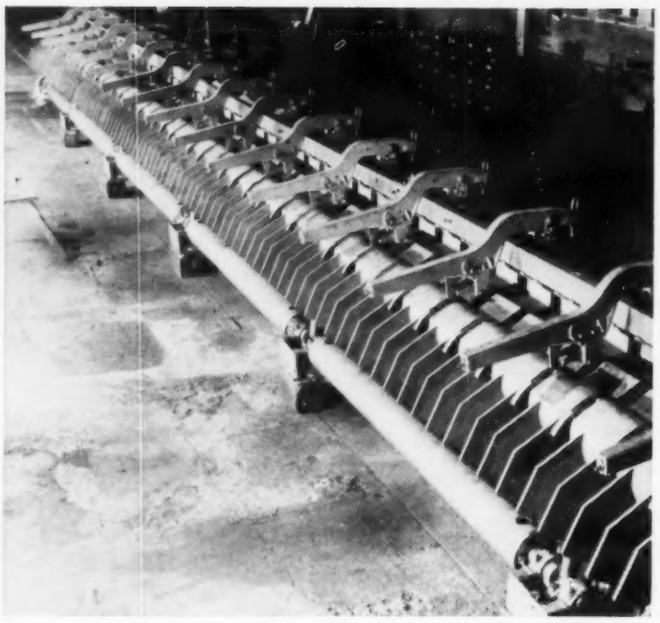
As specialist for 65 years in the manufacture of lubricants for steel making, The Ironsides Company is especially pleased to honor Oscar Maag of The Timken Roller Bearing Company for his great contributions to our industry. It was our privilege, here at Ironsides, to work closely with Oscar Maag as our Company's consultant following his retirement from Timken, and to know him as both a great technologist and good friend. The Ironsides Company, Columbus 16, Ohio.

By the makers of Palmoshield
"the palm tree that grows in Ohio"

J. M. MARQUES



Pinch Roll Unit for 14" Mill



Cooling Bed Runin Table with Overhead Packing Mechanism

in BIRDSBORO mill machinery—the only standard is what's best for your operation

That's why we say that only *special* mill machinery is turned out of our shops. Each piece of equipment is custom-designed. Each step of its manufacture is taken with your needs in mind. And more than 50 years of "customized" service to industry has given BIRDSBORO important know-how with nearly every type of mill machinery made today . . . as well as with the new equipment that automation and higher production quotas will demand. Your Birdsboro representative will be happy to discuss past accomplishments and future possibilities, and how they can help you.

Main Office, Engineering Department and Plant: Birdsboro, Pa., *District Office:* Pittsburgh, Pa.

MM-61-57

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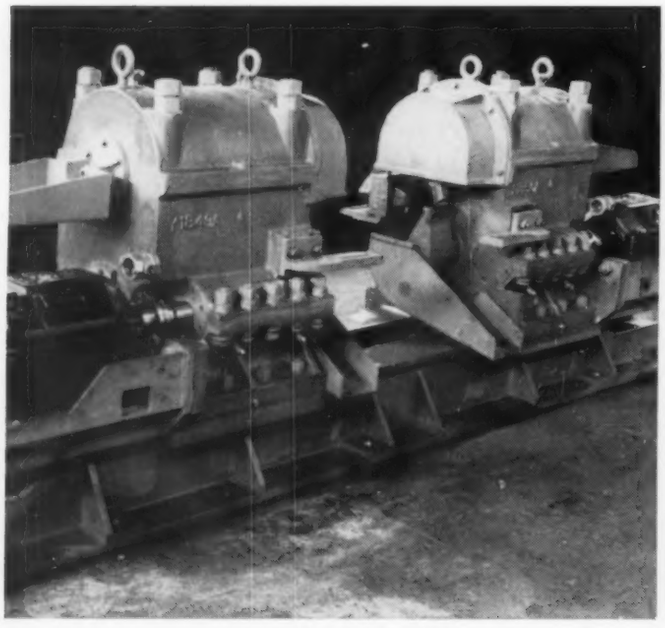
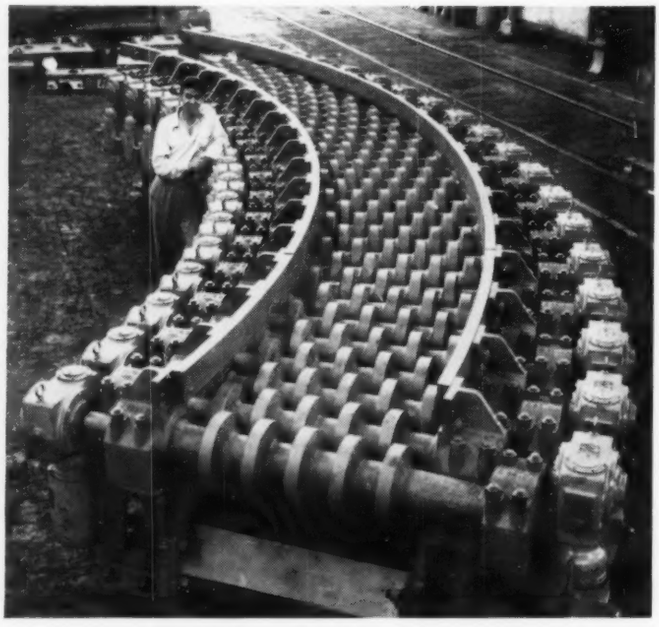
STEEL FOUNDRY AND MACHINE CO.

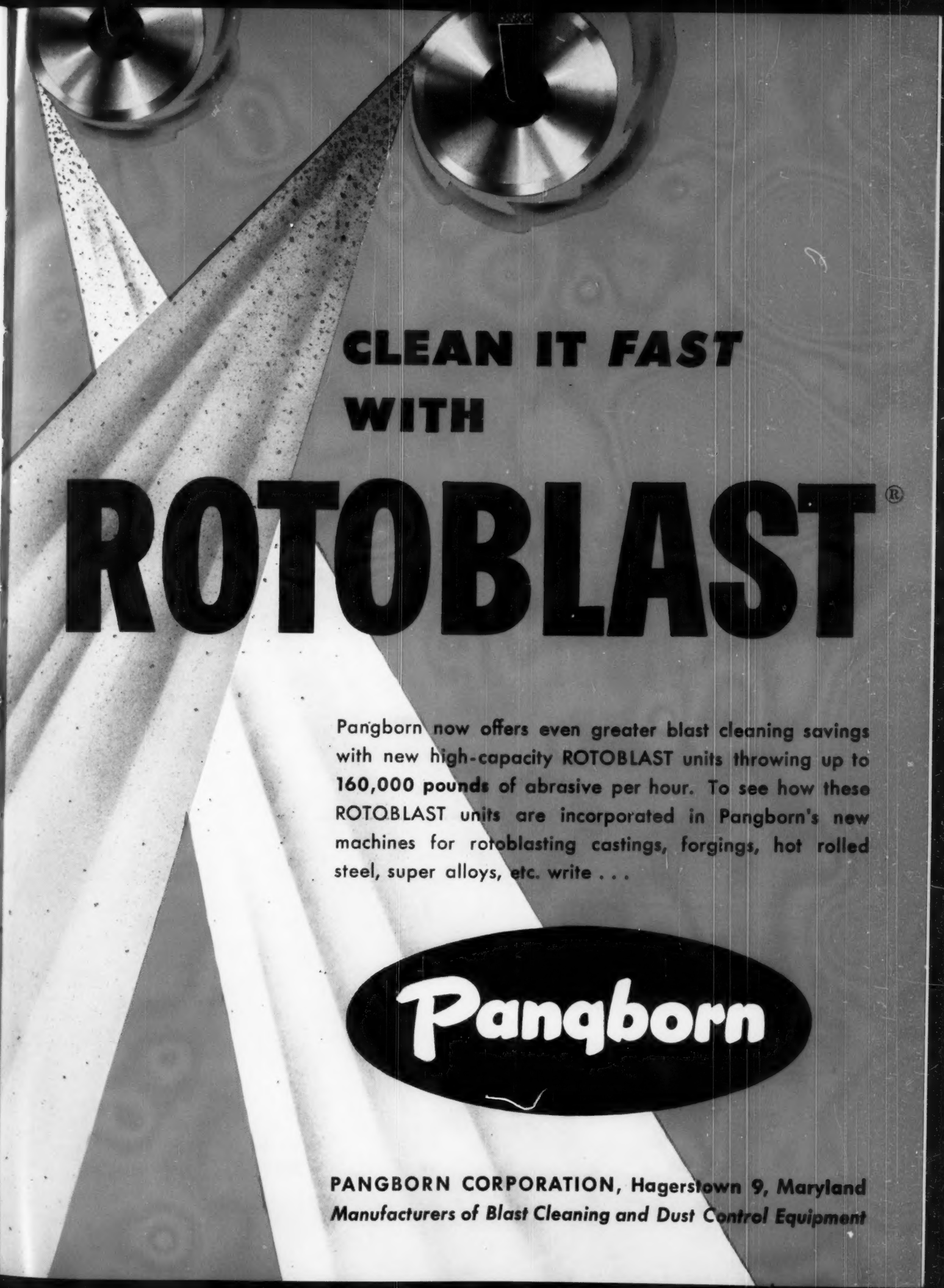
STEEL MILL MACHINERY • HYDRAULIC PRESSES • CRUSHING MACHINERY • SPECIAL MACHINERY • STEEL CASTINGS • Weldments "CAST-WELD" Design • ROLLS: Steel, Alloy Iron, Alloy Steel



Two Flying Shears



Furnace Discharge Table (Curved Section)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WITH
ROTOBLAST®
Pangborn now offers even greater blast cleaning savings with new high-capacity ROTOBLAST units throwing up to 160,000 pounds of abrasive per hour. To see how these ROTOBLAST units are incorporated in Pangborn's new machines for rotoblasting castings, forgings, hot rolled steel, super alloys, etc. write . . .
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A coating in **COLORS** that really

STICKS TO GALVANIZED METAL

RUST-OLEUM®
GALVINOLEUM® COATINGS

Paint peeling off galvanized metal? Here's the *practical* answer to an *everyday* problem!

- *First*— You can apply Galvinoleum right over brand new galvanized metal without etching, without weathering—saving costly, tedious surface preparation.
- *Second*—Galvinoleum provides lasting protection for older galvanized surfaces, too. Just be sure that all former coatings are removed before applying Galvinoleum.
- *Third*— You can beautify as you protect in your choice of four attractive Galvinoleum colors—Red, Gray, Green, Metallic.

Look around! How many galvanized metal surfaces do you have—gutters, downspouts, roofs, siding, heating and air conditioning ducts, etc.? Galvinoleum used now can prevent peeling "headaches" later. Make it a point to check with your Rust-Oleum Industrial Distributor for a free test demonstration or application. He'll be happy to consult with you on your galvanized metal maintenance problems. Attach the coupon to your letterhead for a free test sample and name of your nearest Rust-Oleum Industrial Distributor—there is no obligation.

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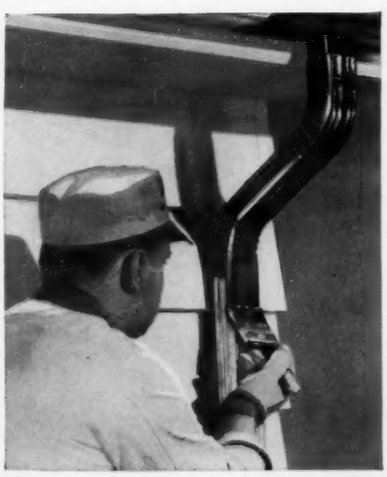
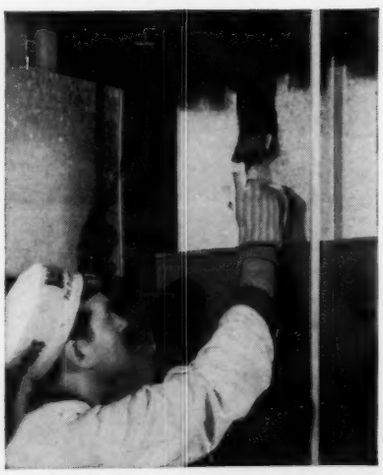
Distinctive as your own fingerprint.
Accept no substitute.

STOPS RUST!®



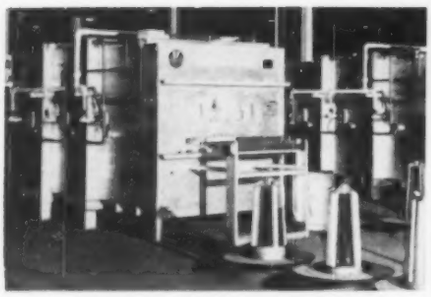


ATTACH TO YOUR LETTERHEAD FOR FREE TEST SAMPLE OF GALVINOLEUM®

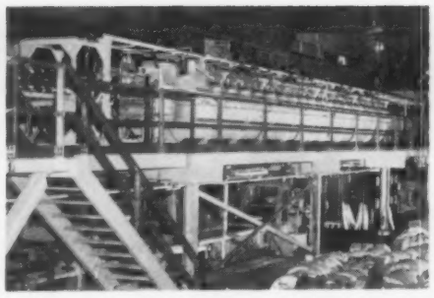
Rust-Oleum Corporation
2651 Oakton St. • Evanston, Illinois

Please send me complete literature and a free test sample of Galvinoleum in the color indicated:

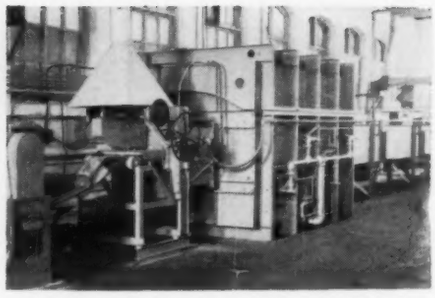
- ☐ Red
- ☐ Gray
- ☐ Green
- ☐ Metallic



An EF multiple tube type furnace bright annealing stainless steel wire, continuously. One of an installation of five stainless steel furnaces we built in a prominent steel plant.



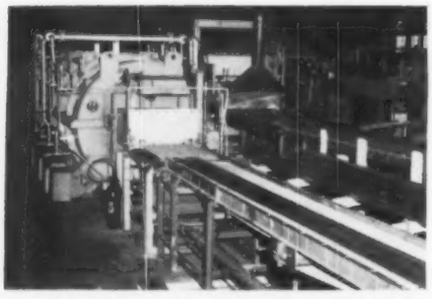
Large capacity EF gas fired furnace bright annealing stainless strip. We build them electrically heated or gas fired for wide or narrow strip, for single or multiple strands.



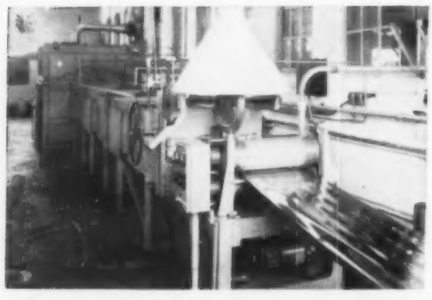
Stainless steel strip in various widths is bright annealed continuously in this EF gas fired special atmosphere installation equipped with an EF gas fired ammonia dissociator.

Bright Annealing Stainless

Tubing, Strip, Wire, Stampings and Other Stainless Steel Products



Stainless Steel Tubing in various diameters and lengths up to 24 feet is bright annealed continuously in this EF gas fired furnace.



Stainless Steel Strip. Wide, narrow and in various types, is uniformly bright annealed, continuously, in EF furnaces — any tonnage.

Stainless steel strip, wire, heavy and fine tubing, stampings, flatware, cooking ware, drawn and other stainless steel products, in many shapes and forms, are being bright annealed, uniformly, economically, continuously and with laboratory precision in EF furnaces of various sizes and types we have built.

Extensive experience with stainless steel problems, backed by over 40 years of practical furnace building experience and thousands of successful fuel fired and electric installations, enable EF engineers to design and build the best size and type of equipment needed for handling any product or production, or for any heat processing requirement.

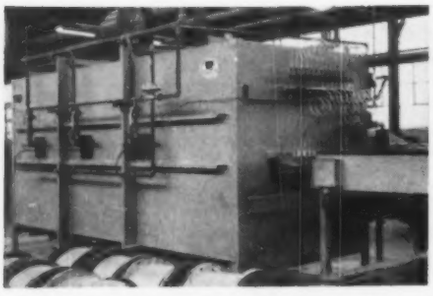
Submit your production furnace problems to experienced EF engineers — it pays.

THE ELECTRIC FURNACE CO.

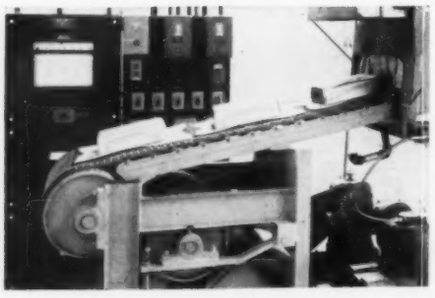
GAS FIRED OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION

Salem - Ohio

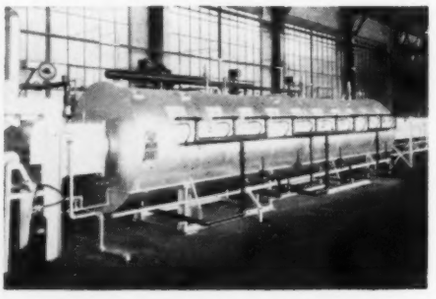
Canadian Associates • Canefco Limited • Toronto 1, Canada



Stainless Steel Wire is bright annealed in this and other EF continuous and batch type gas fired and electric furnaces we build.



Stainless Steel Stampings, flatware, drawn and other products; large, small and in various shapes are bright annealed in EF furnaces



Another type we build for bright annealiag stainless strip. This EF furnace also handles other grades requiring lower temperatures.

self-aligning . . . CAN'T BIND

HOW SELF-ALIGNMENT WORKS. Spherical inner ring, free to align in any direction, assures full load capacity regardless of shaft deflection or support misalignment.

Husky bearings in husky housings adjust immediately in any direction

When high-impact loads deal out punishment, shaft deflection may spell a quick finish for ordinary bearings. But this rugged Link-Belt bearing is *self*-aligning . . . won't "pinch" or bind when misaligned.

Complete protection is provided by effective seals which block entrance of dirt, escape of lubricant. Durable housing—machined as two perfectly matched parts provides easy installation without shims or alignment rings.

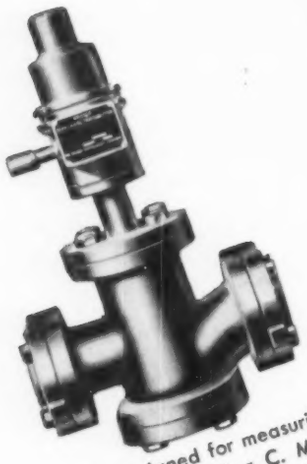
Get full data on Link-Belt's complete bearing line from Book 2550. Ask any of 40 Link-Belt offices or one of our authorized stock-carrying distributors.

Series 6800, 6900, 7800, 7900 roller bearings have internationally standardized boundary dimensions.

LINK BELT

self-aligning ball and roller bearings

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14.441



Area Meter is designed for measuring viscous fluids such as tar or Bunker C. Meter body readings are transmitted electrically to an evenly graduated indicating or recording instrument. Capacity, based on water, varies from 0-150 to 0-2,000 gallons per hour.

***ElectroniK* Flow Recorder** incorporates electronic integration. It is available with air control and can be used with an evenly graduated or square root type meter body or a bell type low-pressure meter.

Interchangeable Range Tubes and interrelated charts permit you to change flow meter to any range without disturbing orifice connections.

Differential Converter is a mercuryless flow transmitter with square root calibration, pneumatic transmission, and infinite rangeability between 5" and 1000" of water. Measures gas and liquid flow or liquid level with accuracy within ± 1%.

Ratio Flow Controller automatically maintains proportions of one or more flows in relation to a primary flow. It records the uncontrolled flow and the secondary or controlled flow on the same chart.

Choose the exact features you require...from the complete line of Honeywell flow meters

Why be restricted to one type of flow meter and possibly have to change your process to fit the meter? The completeness of the Honeywell line of flow meters lets you choose the best possible type of meter for any application... choose the specific features you need from a wide variety.

You can select either square root or linear calibration . . . mercury or mercury-less or area type manometers . . . pneumatic or electric transmission or mechanically connected instruments. Whether you want to meter air, oil, gas, or most any other fluid, you'll find the exact instrument you need in the Honeywell line—a line unmatched by any other manufacturer.

Your nearby Honeywell field engineer can give you valuable help with your flow metering problems. Call him today . . . he's as near as your phone.

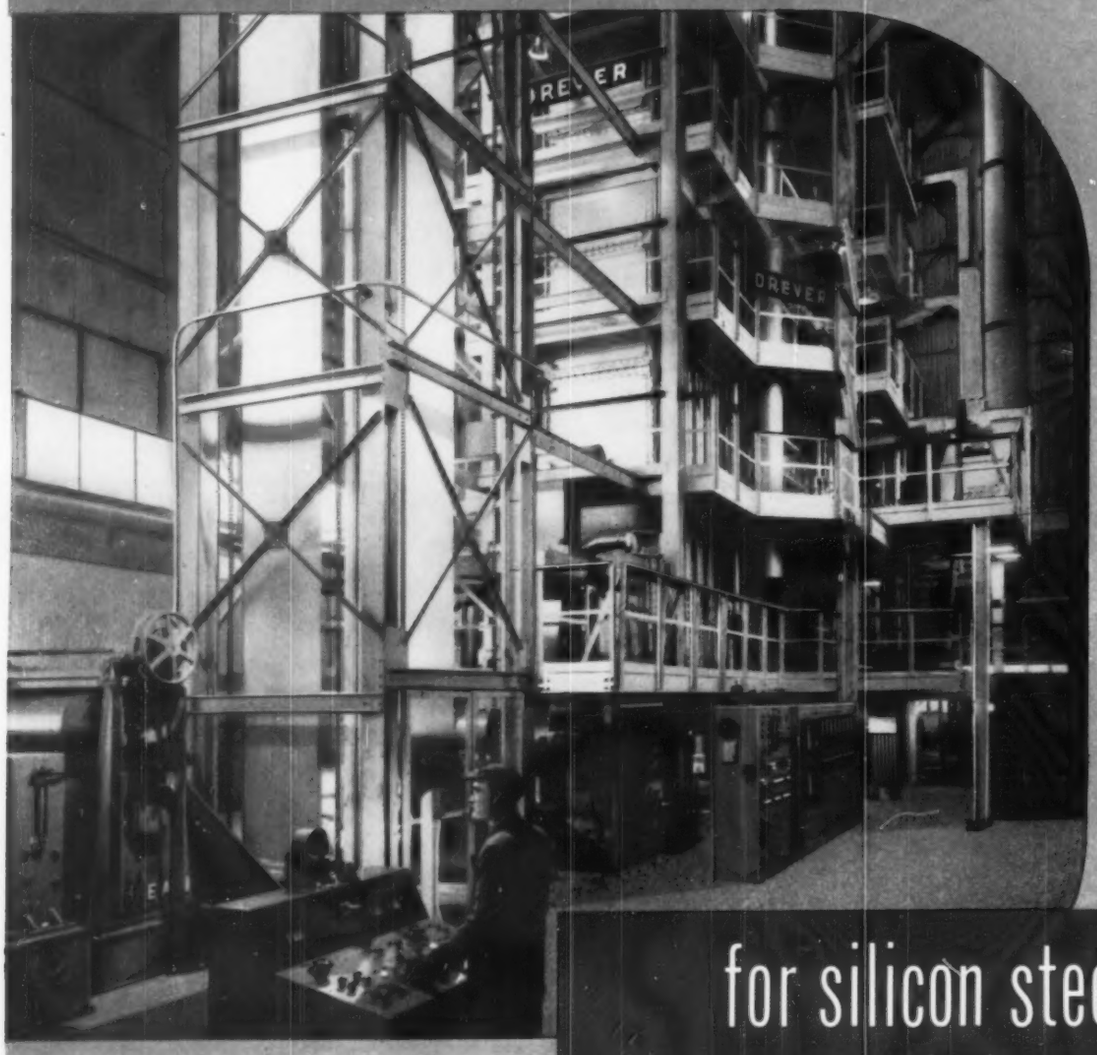
MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Honeywell

H HONEYWELL

First in Controls

DREVER Continuous Strip Annealing Furnace Line



for silicon steel

Delivery end of Drever gas-fired radiant tube heated vertical annealing furnace for silicon steel strip installed at Empire Steel Corporation, Mansfield, Ohio.

This furnace was designed and installed by the Drever Company to produce 8 tons per hour of silicon steel strip. The heating and soaking zones are gas-fired radiant tube heated; the tubes having a connected load of 13,500 CFH of natural gas.

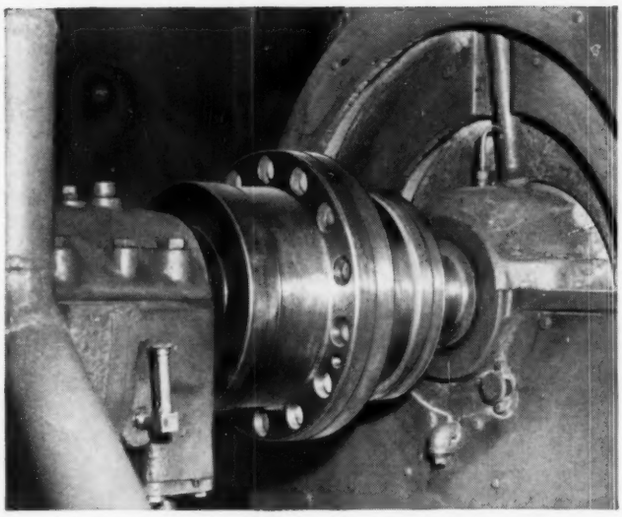
The furnace has been engineered to handle silicon steel strip in thicknesses from 0.017" to 0.025", in widths from 24" to 42", and for speeds from 60 to 180 FPM.

Drever continuous annealing lines for Tin Plate, Galvanized Stock, other Low Carbon Steel and Non-Ferrous Strip in capacities up to 30 tons per hour, provide an economical investment in tonnage production of quality material.

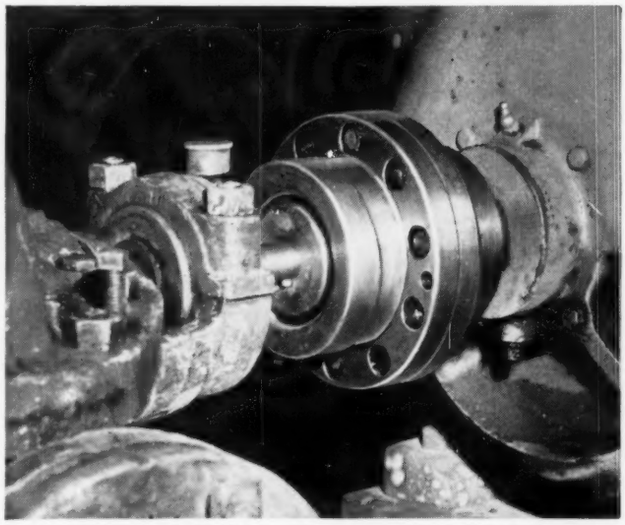
DREVER COMPANY

Red Lion Rd. & Philmont Ave.

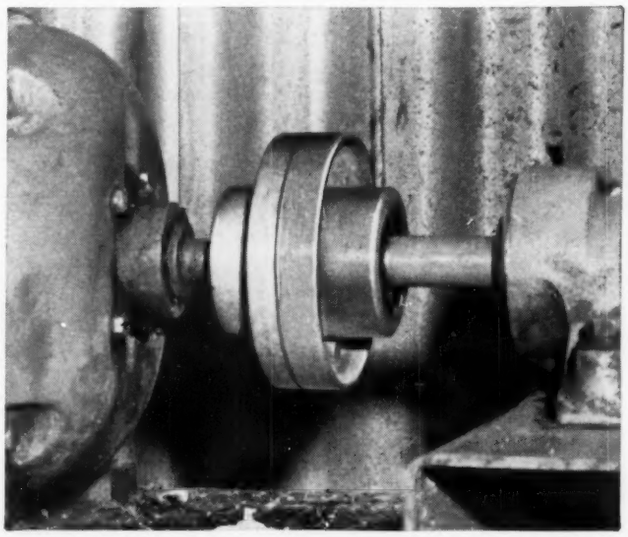
BETHAYRES, PA.



Fast's #4½ Coupling on a 1200 GPM Wilson-Snyder descaling pump. A 1500 hp., 1770 rpm motor drives the unit which operates at a head of 1250'.



Fast's #2 Coupling on a Worthington Type 4-L-1 1000 GPM pump operating at a head of 175'. Pump speed is 3570 rpm. Motor is 60 hp.



Fast's #1 Coupling on a 2500 CFM ventilating fan. Fan motor is 1½ hp. Rpm is 1800.

Detroit Steel Keeps 100 Fast's Couplings at Work with Only Minimum Maintenance

Fast's Couplings have reduced costly downtime and maintenance at Detroit Steel Corporation's Portsmouth, Ohio hot strip mill. Over 100 in number, they range in size from #1 to #20. Many of these couplings have operated with practically no maintenance for six years. Detroit Steel chose Fast's Couplings because of their *sound basic design.*

Here's why Fast's design pays off in low-cost maintenance and trouble-free performance: mechanical flexibility compensates for misalignment. Couplings last longer because there's no metal-to-metal wear. Positive lubrication forms a film on load-carrying surfaces. Metal-to-metal seal keeps out dirt, grit and moisture.

For more details, write to KOPPERS COMPANY, INC., Fast's Coupling Dept., 3001, Scott St., Baltimore 3, Md.

THE ORIGINAL

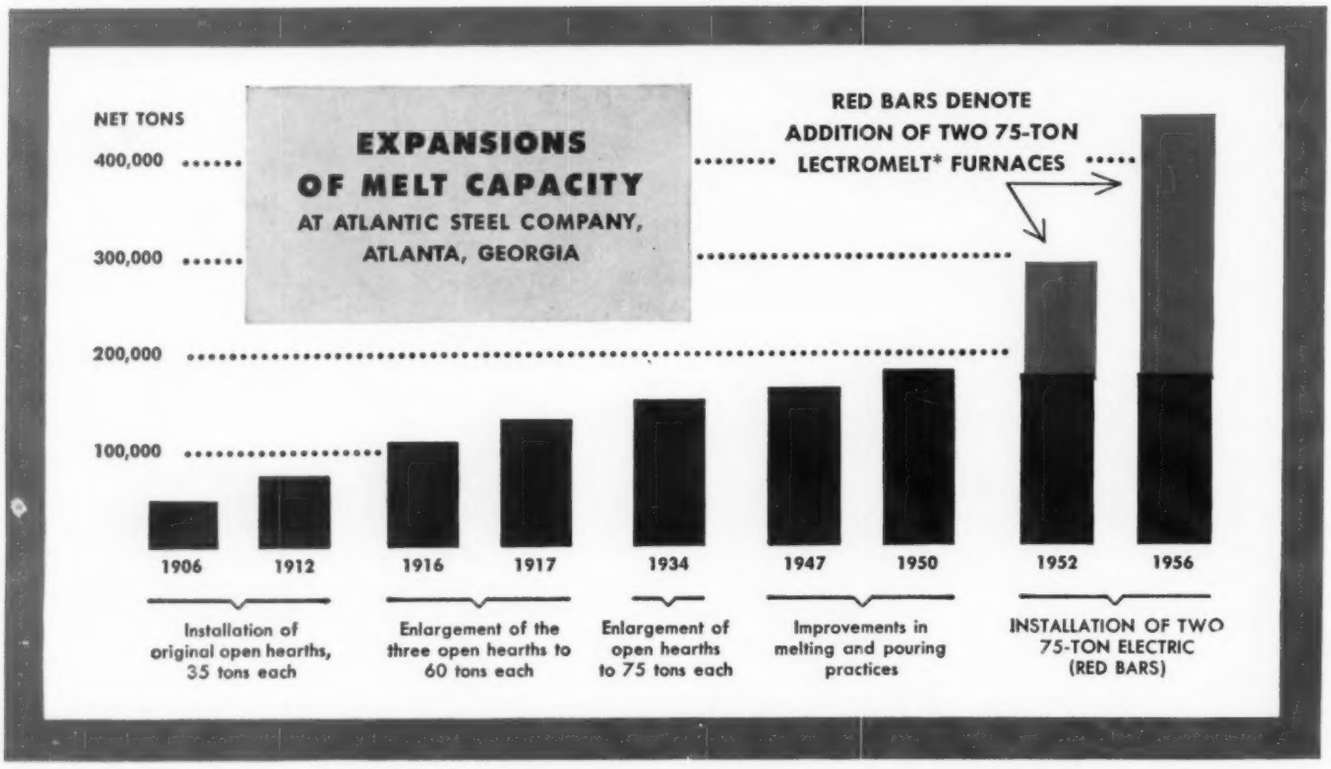
KOPPERS

FAST'S Couplings

Engineered Products Sold with *Service*

ATLANTIC STEEL

compares open hearth and electric furnaces



For equivalent open hearth capacity:

Electric furnace first cost is 40% less.

Space allowed for 3 electric furnaces is ⅓rd less.

Electrics get into production faster.

More precise temperature control and no contamination from fuels.

Faster heats, because charging time is cut in half.

Greater flexibility; need run only to suit demands.

Operating costs are consistently lower; ingots average 5% less.

Catalog 10 describes Lectromelt Furnaces.
Lectromelt Furnace Division, McGraw-Edison Company,
310 32nd Street, Pittsburgh 30, Pennsylvania.

Lectromelt

*Reg. T. M. U. S. Pat. Off.

McGRAW EDISON

CANADA: Canefco Limited, Toronto . . . ARGENTINA: Master Argentina, Buenos Aires . . . ITALY: Forni Stein, Genova . . . ENGLAND: Electric Furnace Co., Ltd., Weybridge . . . GERMANY: Demag-Elektrometallurgie, GmbH, Duisburg . . . SPAIN: General Electrica Espanola, Bilbao . . . FRANCE: Stein et Roubaix, Paris . . . BELGIUM: S. A. Stein & Roubaix, Bressoux-Liege

by HARRY W. McQUAID
Consulting Metallurgical Engineer
Cleveland, Ohio

The Direct Reduction of Iron Ore in the United States

the high investment cost of the blast furnace-open hearth combination has put it on the defensive, and the electric arc furnace is one way of meeting increased steel demand at a minimum capital cost . . . . however, since scrap supplies and prices are so erratic, there is a marked interest in the development of a direct reduction process to assure a dependable and economical supply of the metallics needed by the steel industry.

THE following is a general discussion of today's picture in the United States of the basic problems involved in the direct reduction of iron ore where the main object is a means of the eliminating of oxygen from the ore and the recovery of the iron. This usually results in a product consisting primarily of iron in the solid form with a varying percentage of the usual non metallics found in the ore and any iron oxide which was not reduced. Its principal objective is a lower investment in equipment as well as improved operating economics.

Through the kindness of the A. D. Little Co., The Republic Steel Corp., the National Lead Co., and the Hydrocarbon Research, Inc.—Bethlehem Steel Co., the writer has been able to make a fairly thorough study of the processes discussed. The drawings of the reduction processes based on natural gas to form hydrogen and carbon monoxide as the means for deoxidizing the iron ore are shown with the permission of the Arthur D. Little Co. They will bear careful comparison and study especially if the reaction temperatures are given careful consideration.

The many years of development which have brought the modern blast furnace to its present size and present quality of product have resulted in its zenith today in the fully integrated steel plant with the blast furnace, coke oven, and ore handling equipment completely integrated with the large open hearth and bessemer furnace. By supplying the steel melting furnace with a large percentage of its charge in the form of a hot, highly fluid, molten iron, it was possible to obtain a very marked improvement in the monthly production of the tonnage open hearth as well as much lower costs per ton for fuel, labor, maintenance and other operation expense charges. The whole high tonnage steel production from the open hearth and the bessemer depends solidly on the availability of hot metal and its conversion to steel in these melting furnaces has been reduced to a most exact science. It, however, usually limits the engineering layout of a blast furnace for hot metal to the fully integrated steel plant and makes it necessary for the non-integrated steel plant which confines its melting equipment to the use of cold iron in the charge, to use pig iron which is often shipped for a considerable distance.

In the blast furnace, the commercial iron oxide (ore) is converted to the molten (liquid) state along with an alkaline reagent such as limestone by burning coke with preheated air for combustion. The conditions are such that the reduction of the iron ore by the carbon monoxide formed by the partial combustion of the coke is a relatively slow process badly handicapped by the high percentage of flux which must be melted and the melting of the ore and non metallic under highly reducing conditions.

Another handicap of the blast furnace is the difficulty of getting uniform blast distribution, throughout a burden where fine particles of iron ore are in close contact

with lumps of specially prepared coke. Due to the great demand which the increasing height and diameter of the modern blast furnace has put on improvement in coke quality and uniformity and on ore preparation and burden uniformity, the future development of the blast furnace seems to become more uncertain every day. As long as the necessary quality in coke and iron ore, however, can be made available as well as tonnage oxygen for blast enrichment, the present blast furnace would seem to be quite securely entrenched. But high grade coking coal is becoming a definitely scarce tonnage material except for a few special locations, and the investment cost per ton of hot metal made in even the best furnaces is becoming almost prohibitive, if we include the necessary coke ovens and all accessory equipment. For over five hundred years the blast furnace has been developing to its present status, but now has apparently reached the stage of its existence where every possible commercial step will be taken to replace it with much lower cost equipment. Usually when an industry wide need has been found for an improvement in a process or a product the origination and development of such an improvement is soon found. For these reasons almost every hot metal and pig iron user in this country and Europe is patiently waiting for the time to come when iron ore can be reduced directly to either liquid or solid iron in low cost equipment.

As a matter of fact so is the buyer of steel scrap for remelting where the price is apparently all that the market will bear and where it is difficult to predict more than a few months ahead what the price of steel scrap will actually be.

The first one to be attracted by such direct reduction equipment ought to be the electric furnace melt-shop dependent now on the uncertainty of the cost of scrap in the future. The use of the direct reduction process to stabilize the price of scrap should be of the greatest interest to every electric furnace high tonnage operator in the country. While liquid iron would be an advantage in replacing scrap in the electric furnace, in the solid form it would also be desirable.

Due to the high investment cost which has now been reached in the installation of high tonnage modern open hearth furnaces and all their accessory equipment of blast furnace, coke ovens, and ore and coal handling facilities, the modern thinking has been in favor of large electric arc furnaces. This is especially true where the present melting plant consists of a well balanced fully integrated open hearth battery already at the full limit of existing capacity of present hot metal production equipment. Here the addition of one or two large high powered electric arc furnaces, each of which can average more than twenty-five tons per hour of semi-killed merchant bar ingots from available scrap, is most attractive. This is especially true when we examine the investment per annual ton and in this case the open hearth looks anything but attractive. The relative advantage of the open hearth or electric furnace is dependent on the relative cost of hot metal and scrap, and until we know for certain the costs in the future of hot metal and steel scrap, we have no way of making a really certain correct choice of one over the other.

It is quite probable, however, that any large installation of high tonnage electric arc furnaces throughout the industry will immediately result in an increase in scrap demand and prices which will be all that the traffic will bear. Then any advantage of the electric furnace in the whole steel industry will be reduced to little. The open hearth furnace at this moment is on the defensive because of its dependence on liquid iron (hot metal) as well as scrap. In our consideration of the direct reduction of iron ore, we must not forget that if the product which results from such a process is above 95 per cent in iron content and low in carbon and silicon, we wind up with a high iron product with a high melting point, and one which is primarily competitive with scrap and not with hot metal or pig iron. In fact, directly reduced iron ore in the form of a very low carbon, low silicon iron of high purity will not fit at all in the open hearth economy, but will fit much better into the electric melting picture where its economic position would be compared directly with available scrap. If the facts are known, the electric furnace as well as the open hearth would be much better off if a relatively high carbon, low silicon iron were available, preferably as hot metal, but even as a cold pig charge.

As a matter of fact many processes for the direct reduction of iron ore to produce a satisfactory charge material to replace scrap or blast furnace pig iron have been proposed in the past forty years. The first objective of such direct reduction is to obtain relatively low cost equipment which will produce a commercial grade of iron which will be satisfactory to replace cold pig iron or good grade steel scrap and which can be somewhat independent of coke or at least high grade special quality coke. It might be especially desirable if small yet efficient direct reduction plants could be built at a relatively small investment cost as compared to the modern large blast furnace and operated in parts of the country where high grade coking coal would be difficult to obtain.

The modern blast furnace is doing a good job in producing hot metal or cold pig to use in an open hearth and the principal improvement which might be made in it for the open hearth would be to drop the carbon (not below 2 per cent) and eliminate the silicon and sulphur. Such a charge would be ideal not only for the open hearth, but also for the electric furnace especially for heats which must pass cleanliness tests and be used as an alloy steel base. In practically every open hearth or electric furnace quality heat, a good carbon boil is desirable and low silicon and sulphur in the charge helpful. This is to insure removal of unwanted non metallics.

There will be immediately some who will rise to note that unless low sulphur fuels are used on the open hearth and in the scrap, the low sulphur, low silicon hot metal or pig is probably a wasted refinement. However, it is my experience that a really low sulphur and low silicon hot metal or pig addition, when associated with a good carbon boil is very helpful in getting good looking billet etches, especially in heats on the hot side and not too fully deoxidized.

The direct reduction of iron ore by hydrogen does not usually fit too well into the large basic open hearth operation because of low carbon but should be of much greater importance to the cold pig and acid open hearth shop. It is for such applications that we must consider it. In other words the development of an industry wide application of the directly reduced iron ore by hydrogen

would not seem probable because of the economical dependence of the modern large tonnage open hearth or bessemer furnace on high carbon, hot metal as its major charge. It would seem to follow that if some other means than the blast furnace for reducing iron oxide (ore) to produce an important high tonnage charge for the open hearth or bessemer is developed, it will be economically necessary to use carbon or carbon monoxide as the basic reducing agent, to produce the iron in the liquid form and to control the silicon to make it as low as possible to best suit the melting furnace requirement. The logical approach to such an end point would seem to be to melt the highly concentrated iron ore under the very best fuel and oxidation conditions of oxygen-enriched blast high temperature combustion, and to treat the largest possible surface of the molten, superheated ore per ton, with incandescent carbon and superheated flux. This would seem to be a problem for the best combustion engineers and furnace builders. As a matter of fact the reduction of iron ore (oxide) by treating it in the molten state with carbon is becoming a more important means of obtaining iron from the ore every day and promises someday to become a strong rival of the blast furnace in areas where high grade coke is difficult to obtain. In fact, under certain conditions where transportation charges, power and other costs are favorable as they seem to be in many locations, especially in Europe, the direct reduction of iron ore by smelting in the submerged arc type of electric furnace is more economical than in the blast furnace. This would be especially true if we had to engineer and build the blast furnace from the ground up. Here the high cost of building a new blast furnace complete involves carrying (fixed) charges which make the submerged arc furnace look especially attractive as compared with the new blast furnace.

The deoxidation of molten and superheated iron ore with carbon in an electric arc furnace occurs with tremendous rapidity if the carbon-iron ore mixture is intimate and a violent reaction can be permitted. Ordinarily the rate of reaction can be regulated to suit the operator by controlling the temperature and the rate of carbon feed into the really active bath. The problem becomes one of two distinct phases, first to produce highly fluid, molten, concentrated, iron ore and second to control closely the reaction of this highly fluid iron ore concentrate with finely divided carbon intimately mixed with it. So far the most successful reduction to practice of this method of ore reduction has been in Norway and Sweden, Italy and other parts of Europe as well as South America.

Typical of these would be the modern electric arc furnace using special electrodes which melt and superheat the ore in contact with crushed coal, usually low grade anthracite in Europe. The problem of melting a crushed iron ore mixed with crushed coal in a modern arc furnace is not especially difficult and as long as the ore is molten and the temperature is high enough the carbon will react most rapidly with the oxygen in the fluid ore and reduction is only a matter of a few minutes. While the submerged arc electric furnace is being accepted as probably the best means of developing the direct reduction of molten iron ore with carbon, some consideration must be given to cheaper means of melting the ore and obtaining the temperature and fluidity necessary to insure a fast reduction of the iron ore by the carbon and the separation of silica and other non metallics.

One such method for instance would be oxygen-enriched gas or oil burners or even powdered coal using oxygen for enrichment. Here the cost of the use of oxygen could be judged by comparing it with the cost of electric power in the submerged arc furnace. If we estimate from some figures available a power requirement per net ton of 2200 kw, it would require approximately 8000 cu ft of natural gas to produce the same heat input into the ore. To burn this gas for the same cost at the burner, it would be possible to replace 85 per cent of the oxygen in the air for combustion with oxygen from a standard steel mill oxygen plant. Whether this much oxygen would be needed is very doubtful, but if to the cost of the electricity we add the cost of the electrodes used per ton, we would have enough to permit practically 100 per cent oxygen enrichment of the blast for melting which would not be at all necessary or desirable. In fact much of the heat required would be obtained by the combustion with oxygen of some of the carbonaceous material mixed with the ore for its reduction. Between the combustion of the fuel gas entering through the burner and supplied with oxygen, and any excess of oxygen available combining with the carbon in the charge, there should be no difficulty in melting the ore for its reduction. Its melting and superheating by gas together with combustion of the carbon mixed with it will insure an immediate deoxidizing reaction which will proceed to completion if temperature, carbon and contact are all sufficiently high. There has been much discussion in the past of the difficulty in melting magnetite iron ore under oxidizing conditions and this has been used as an argument against the first melting of iron ore and its reduction with carbon in the superheated liquid form.

It would seem that with the high temperature possible with complete combustion using oxygen enriched blast and natural gas, the heating of a mixture of iron ore and carbon to well above the melting point of the ore is economically possible, especially when compared with electricity as a fuel. It is interesting to note that at one stage in the preparation and concentration of taconite ore, one of the published methods shows a heating of a relatively large mass of unconcentrated ore to approximately 2300 F, and it is interesting to speculate on what would happen if it was heated to above the melting point while well mixed with a pulverized carbonaceous material.

Assuming that a mixture of molten, highly liquid iron ore and carbon is made available by some means or other, it should be a relatively simple problem to obtain the complete elimination of oxygen and a highly liquid charge metal for the open hearth or electric steel furnace. For this reason it would seem that the production of hot metal or pig iron from ore might some day soon become quite common throughout the non-integrated properly located steel plants. In fact in some fully integrated plants the present investment economics of the blast furnace and open hearth combination will cause the steel plant operator to give much more thought to the submerged arc electric or other ore melting means and electric furnaces for finishing. This is especially true since the apparent discovery that the savings in power will pay for almost any degree of ore concentration attempt-

ed, and if the real value of the gas produced is duly obtained and credited it becomes difficult to justify any other method. It is interesting to note that the first attempts in this field that the writer was connected with over ten years ago indicated as low as 1300 kwhr for a net ton of iron when highly concentrated magnetite ore was reduced with carbon in an electric furnace. Now, we are told, 1100 kwhr will be closer to the real power requirement per net ton of iron produced in this country. This, if true, makes the making of electric furnace hot metal or pig iron a very important economic development in the steel industry with the submerged arc furnace as the basis for the melting stage in the ore reduction treatment.

It is our understanding that the Republic Steel Co., a leading electric furnace steel producer in combination with the National Lead Co., a large non-ferrous metal producer has now reduced to practice an iron oxide reduction process producing a melting stock for use in steel mill melting furnaces supplying any desired grade of steel.

Right now is really just a little early to express any opinion of the actual merits of this direct form of ore reduction in our country, but all things considered including the experience abroad, would indicate that it is in good hands. The publicity which is expected to be given it in a short time will show that a new tonnage method of reducing iron oxide to the metal iron with carbon has now been developed and that it will be rapidly taken over by those electric furnace operators to whom it is especially suited. It would be of importance to those interested in this subject if they would study a discussion recently published by Dr. E. C. Wright of the University of Alabama entitled "Electric Furnace Pig Iron," and also the chapter on electric pig-iron smelting by A. G. E. Robiette in his book entitled "Electric Melting and Smelting Practice." These give some of the more basic information on the subject of ore reductions by the electric melting furnace. Much more complete data covering the work of the National Lead Co. and the Republic Steel Corp. will probably be published in the near future.

While there have been many unsuccessful attempts in the past to develop satisfactory direct reduction methods of producing iron from iron ore these have been of some value in indicating what should be avoided in the development of a commercially successful direct reduction process. The advances made in ore concentration and means of removal of gangue material before the reduction is attempted have improved greatly the chances of success. The preparation of the concentrated ore by finely dividing it has improved the reaction rate and thoroughness of the reduction reaction. Its final mixing in the highly concentrated finely divided form with the reagent selected to remove the oxygen has now been developed to the point where the removal of oxygen from the ore and its complete reduction can be assured.

There are several approaches to the problem of ore preparation for reduction, the most logical being the magnetic concentration of a magnetite ore. Here the finer the division of the ore the easier it is to practically completely remove non metallic gangue and obtain the more highly concentrated ore. With the practically pure iron ore in a finely divided form, it is in the best form for complete deoxidation, but in the most difficult form for handling in processing. If hydrogen is the reagent used to separate the iron from the oxygen with it in the ore, the practice as indicated by Udy and Lorig is simple provided the pulverized material can be handled. The time required for the complete reduction of an oxide of iron in powdered form by hydrogen will depend to a large degree on the size of the largest particles and the access to them of the heated hydrogen.

The speed and completeness of any chemical reaction involving high temperature with iron ore is to a large degree determined by the area per ton of the hot metallic compound in contact with the reagent, the intimacy of the contact between them, and the temperature of the reaction. The more thorough the mixture and the more finely divided the contacting materials the more rapidly the reaction proceeds to completion at a given temperature. However, handling finely divided materials in volume is difficult, especially at high temperature and requires in some cases special provision for suspension. At any rate fluidization and fine particle suspension offer attractions to those who are trying to encourage complete and rapid reaction at high temperature of solid particles such as iron oxide and a gas such as carbon monoxide or hydrogen at high temperatures. Such processing requires special design in equipment and techniques, because of the time and temperature required to maintain the intimate contact of the finely divided solids and the gas.

Another approach which offers some attraction to the less venturesome operator is to resort to pelletizing and circulating and recirculating the heated gaseous reducing agent through a stack of pellets of finely divided ore concentrates until the oxygen in combination with the iron is all removed as water or carbon dioxide. A properly prepared pellet acts quite satisfactorily especially when the reducing gas is hydrogen. A highly concentrated magnetite ore for instance can be finely pulverized and pelletized using an organic oil binder and then oven baked to produce a strong but relatively porous pellet which can easily be reduced with hydrogen at just under 1100 F, as indicated by Udy and Lorig. Hydrogen because of its high affinity for the oxygen in the iron ore at this temperature provides the most excellent reducing agent. The high specific heat of hydrogen and the ease of separating the steam formed by its oxidation which permits recirculation after condensation are two important factors in the use of hydrogen to produce "direct" iron. By proper careful temperature control, complete reduction of the iron in the ore to metallic iron can be obtained in about five hours. To prevent the formation of pyrophoric iron, the reaction temperature at the end of the reduction cycle is raised from 1100 to 1650 F and the system is then cooled to room temperature in a hydrogen atmosphere. The result is what seems to be a completely stable iron pellet having an iron content of approximately 99 per cent when reduced from highly concentrated New York State magnetite ore. The low temperature is a great advantage because of the absence of fritting or sticking. However, its cost means that for many commercial applications, especially tonnage uses, economics requires that we must seek a cheaper reducing agent than hydrogen and it is for this reason that other gases are considered.

The gas which is usually the first choice as a reduction medium when it comes to removing the oxygen from

iron oxide is carbon monoxide. This is primarily due to the low cost of carbon monoxide and its widespread availability. Carbon monoxide in tonnage quantities can be obtained in various ways, but the simplest is the partial combustion of coal or coke.

At any rate, no matter what method of iron ore reduction we study with carbon, carbon monoxide, or hydrogen, the principal factors we meet in our efforts to improve the process are the intimacy of the mixture, the continual removal of the reaction products and accurate control of the temperature. The intimacy of the mixture depends on the particle size and the mixing of the reagents required. This thinking would naturally lead directly to the fluidized solids technique, and it is in this field that the greatest efforts are now being made. It lends itself primarily to the reduction of iron oxide by hydrogen which reaches its maximum effectiveness at a temperature of approximately 100 F as shown by Udy and Lorig. This temperature varies with the pressure and as the pressure increases, the intimacy of the contact of the reducing gas and the particle of ore increases and the result is a definite increase in the rate of deoxidation of the iron oxide.

Nearly fifteen years have been spent in developing the direct reduction of iron oxide with hydrogen by Hydrocarbon Research, Inc., and this intensive work has resulted in a process which gives every indication of becoming economically and practically acceptable as a leader in this field. These years of effort and experience have provided the basic data on which the successful commercial reduction of this process to practice is built.

This is the case in the removal of oxygen from the iron ore concentrates as it occurs in the H-iron process developed by Hydrocarbon Research, Inc., in co-operation with the Bethlehem Steel Co. In this process the concentrated finely divided ore is carried in a semi-continuous or intermittent manner from a storage bin to a charging hopper and then carried when needed in a stream of pressurized hydrogen to the top of the reducing chamber which consists of two or more sections, one above the other, with the incoming fluidized ore passing downward from one section to another as needed. Preheated hydrogen at approximately 1000 F passes upward through the pulverized ore in each section of the reducing chamber as a multitude of bubbles which keep the pulverized ore agitated and insure a good contact between the pulverized ore and the hot hydrogen. As the hydrogen leaves the reducing chamber with a high steam (vapor) content from its reaction with the oxide, it is passed through a heat exchanger to transfer as much as possible of its heat to the hydrogen being recirculated to the reducing chamber. After leaving the heat exchanger it is cooled to 100 F and the water removed. It is this water which is formed by the combination of the hydrogen and the oxygen in the iron ore and the rate at which it is separated in the condenser is a good indication of the efficiency of the reducing chamber. After the water is separated, the hydrogen is scrubbed and recirculated with the help of fresh hydrogen which must be added to make up that lost by combining with the oxygen in the iron ore.

This process is fundamentally sound and apparently quite well reduced to practice so that its position in the industry will depend on the economics of its operation. These will depend to a large degree on the location of the plant as regards fuel supply, the availability of fine iron ore concentrates, and the use to be made of the direct reduced iron (H-iron). It is usual to assume that approximately 25,000 cu ft of hydrogen are required per ton of reduced iron, the amount varying with the type and condition of the ore being reduced. I have known of one test operation where with extra high grade concentrate the measured hydrogen consumed per ton of iron produced was claimed to be close to 20,000 cu ft at normal temperature and pressure. It is quite possible that as the development in this field of ore reduction takes place that the hydrogen requirement on a commercial basis will be below 25,000 cu ft and might approach 20,000. It is not a difficult task to arrive at an estimate of the direct reduction costs for the "H-iron" product which would at least for the present find its initial tonnage application in the electric arc furnace special low sulphur charge, and its principal competition in extra high grade scrap. A study of the costs available would indicate that the production of a high carbon, low sulphur charge, such as "H-iron," should be carefully considered by every electric furnace melting plant producing low sulphur special steel as one means of insuring some stability in the cost of the charge which goes into the melting furnaces. It is especially attractive in areas of high scrap costs and in areas of low natural gas costs. This would indicate an attractive field in Pittsburgh because of high scrap costs and Texas because of low fuel gas costs.

While a study of the economics available would indicate attractive economies in most electric furnace operations, studies have shown not only the H-iron but other hydrogen reduction operations can apparently be reduced to a practice which will produce a melting furnace charge which can come close to economically replacing No. 1 and No. 2 heavy melting scrap at present prices in almost any furnace. On this basis alone, the hydrogen reduced iron ore seems to have a reasonably bright future as long as steel scrap keeps its very sensitive relation to demand and supply. It should have the very best wishes and interest of every electric melting furnace operator.

With the increasing tendency to develop the availability of higher grade ores by increased concentration of the lower grade ores and the direct effect which this has in improving the hydrogen reaction, it will be found that the reduction of iron ore with hydrogen will become of greater interest all the time. Wherever low cost hydrogen can be made available, this process will be given careful consideration especially in the production of a charge material to compete with high grade scrap.

At the present time natural gas is available as one source of low cost hydrogen, which is produced by the Texaco-H.R.I. "Partial oxidation" method or by the reaction of natural gas with superheated steam. Hydrogen can also be produced from fuel oil by the Texaco-H.R.I. "Partial oxidation" process. By any of these methods the gases formed consist primarily of hydrogen and carbon monoxide. In some processes, both gases take part in the reduction process. In others, carbon monoxide is converted to hydrogen by reaction with steam, and hydrogen alone is used in the reduction process. Any hydrogen which does not combine with oxygen

in the iron ore as it passes through the reducing reactor is recirculated through the reduction equipment. An advantage of a process using hydrogen alone, rather than a mixture of hydrogen and carbon monoxide, is that water is much easier to remove from recirculated hydrogen than carbon dioxide, the product of iron ore reduction reaction when carbon monoxide is used. Hence recirculation is considerably less expensive if hydrogen alone is used in the reduction process.

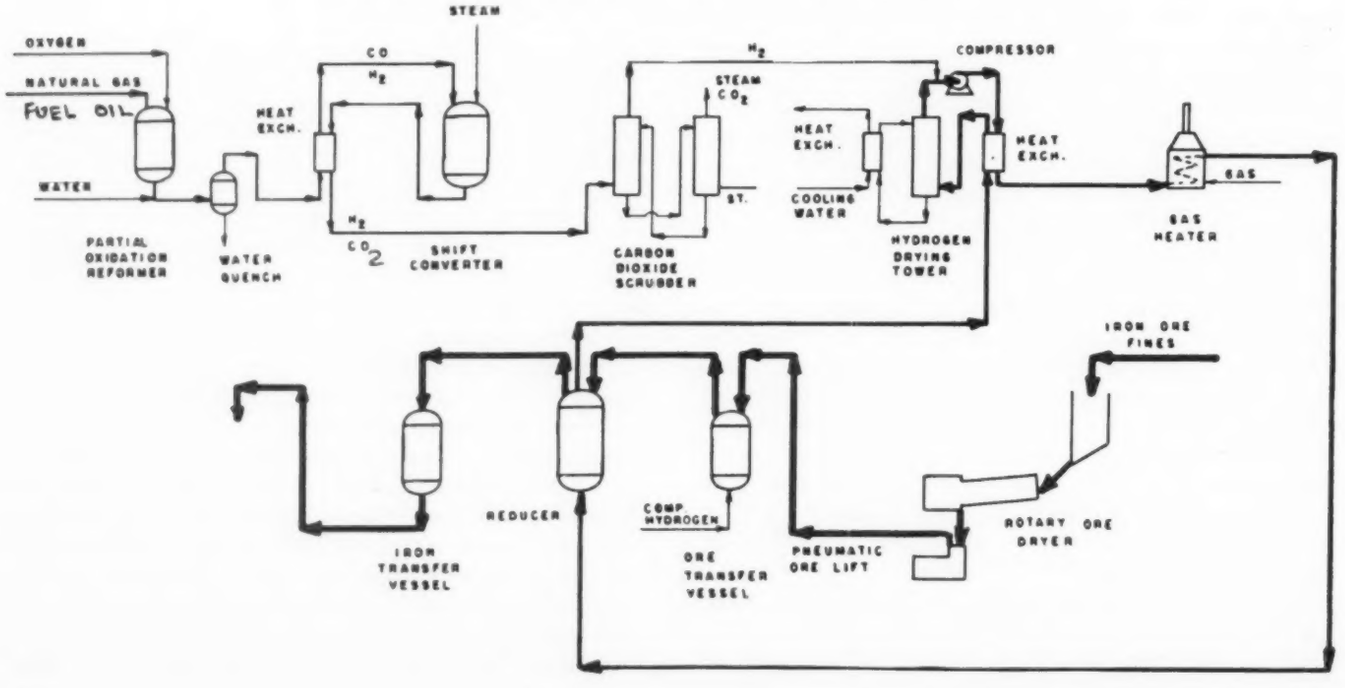
Hydrogen and carbon monoxide, admixed with nitrogen, can be produced by reaction of natural gas with air. Use of hydrogen and carbon monoxide in this dilute form means that reducing gases can be passed only once through the reduction equipment, since removal of water and carbon dioxide in order to permit recirculation would be prohibitively expensive.

Of the methods of iron ore reduction which depend on a gas reaction with the ore all depend to some degree on the fluidized solid-gas mixture to insure an effective and speedy reaction between the reducing gas and the iron ore. There are several proposed methods of reducing the gas-iron ore reaction to practice, and we can discuss here three which are being actively worked on today.

These three would include the process of the Hydrocarbon Research, Inc., which has a large scale pilot plant in operation at Trenton, N. J. This is being operated in cooperation with the Bethlehem Steel Co. Another development would be that of the Esso-Little process which is a joint venture of the Standard Oil Co. and the Arthur D. Little Co. The third gas-iron ore reduction method would be that of the United States Steel-Nu-iron process which is being developed, so we are told, at South Chicago. It is interesting in studying the information available concerning these three processes which have the same end product to be made and the same raw materials to work with, how much they vary in some details. They all depend on finely dividing the concentrated iron ore and carefully mixing with a gas which varies somewhat in composition, temperature and pressure. If hydrogen is the gas which is the principal factor in removing the oxygen from the iron ore, it has been claimed that there is only a very limited range of temperature over which the reaction will proceed to completion and 100 per cent of the oxygen will be removed from the iron ore. This temperature is fortunately under the sintering range and at normal pressure is close to 1050 F. At increased pressure the reaction temperature for 100 per cent reduction can be dropped as is the case in the H-Iron process. Here the pressure is approximately 400 psi and the temperature close to 900 F. In the other two methods named above, the reducing gas is a mixture of hydrogen and carbon monoxide and the temperature higher and the pressure lower than with the H-iron process. In the Esso-Little process, the fluid bed mixing of gas and finely divided dry ore is used with the reaction chamber at 1500 to 1600 F. In this process the natural gas is preheated to 600 to 900 F, and the air for partial combustion to 1500 to 1600 F, which preheating plus the heat obtained from the combination, is sufficient to keep the ore in the fluid bed in the 1500 to 1600 F carbon monoxide. The hot ore passes downward through the gas formed from the partial oxidation of the hot natural gas and is reduced, after which it passes through a product cooler, and then on into a briquetting press.

The Esso-Little process differs from the H-iron process in that the excess reducing gas and gas from the reducer is not recirculated. In the steel plant installation there would be plenty of applications for this gas as a fuel and an important credit thereby obtained. It results also in an important simplification of the equipment. The development of this process represents a great deal of background work and experimental work at the Massachusetts Institute of Technology in connection with the use of the fluidized bed technique in the

Figure 1 — The H-iron process recirculates the hydrogen gas.



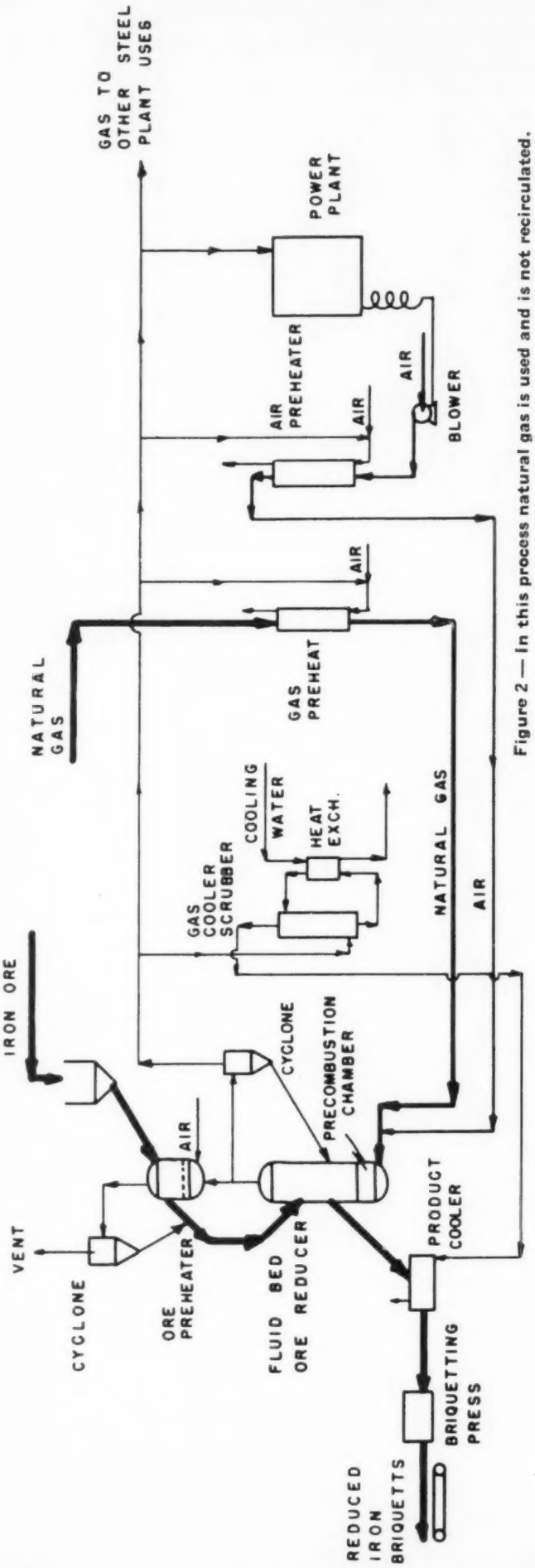


Figure 2 — In this process natural gas is used and is not recirculated.

catalytic cracking of petroleum. While this process has much to recommend it and must be given most careful consideration in the installation of a large tonnage practical plant, it is of interest to speculate on why the temperature range of 1500 to 1600 F was adopted as the correct temperature range for the reduction center.

Figures 1 and 2 show the schematic drawing of the Hydrocarbon Research, Inc. iron ore reduction unit and the Esso-Little reduction unit. It is evident from a careful study of these drawings that the principal difference is due to the reduction gas used and its handling. The high calorific value of the natural gas-air combination at 1600 F in the Esso-Little process makes it more practical to use it as a fuel than to recirculate it. Also it might be that since the reduction gas is not recirculated, the problem of nitrogen dilution can be avoided and the use of air-natural gas combination as the reducing gas becomes practical.

In the case of the U. S. Steel-Nu-iron process, it was difficult to find any results from practice but it was possible to study a schematic drawing made from patent drawings in patents granted to E. H. Shipley in June 1956. Here the two-stage reduction chamber receives the finely divided ore concentrate which has been preheated in two steps to 1700 F. The bottom reduction chamber receives a preheated mixture of carbon monoxide and hydrogen produced by a combination of superheated steam and natural gas which reacts with the heated ore to remove oxygen and to maintain a temperature of approximately 1300 F. It, with the reaction products, moves up to the top reduction chamber to initiate the reaction, whereby the remainder of the oxygen is removed from the ore. The gas from the reduction chamber is recirculated after being cooled, cleaned and the water vapor removed. It is understood that U. S. Steel in its current research is employing hydrogen as the reductant, rather than the mixed gases described by Shipley. Little is known of the possible application to tonnage reduction plants of the Nu-iron process but it would seem a little trouble might be met with in obtaining really complete deoxidation of the iron ore at the temperatures given. This for some applications is not too much of a disadvantage as in the steel melting furnace a combination of iron oxide and metallic iron would in some cases be desirable. The oxide present would be useful in most heats of low carbon steel in reducing carbon from a high carbon charge and take the place of a deliberate ore addition.

It is quite obvious that the production of a reducing gas from natural gas offers at least three ways of procedure. In the H-iron process the partial oxidation of natural gas with oxygen is used. This produces hydrogen plus carbon monoxide with very low nitrogen, the carbon monoxide is changed with steam to hydrogen and carbon dioxide and the carbon dioxide is removed and the "off" gas from the reducer is recirculated. In the Esso-Little process, partial combustion of natural gas with air is used and its products react with the heated ore particles. The gaseous products which include nitrogen are *not* recirculated but are used as a fuel gas. The U. S. Steel-Nu-iron process apparently uses a heated mixture of steam and natural gas which reacts to form hydrogen, carbon monoxide, and other incidental products.

It seems to be apparent that several approaches to the

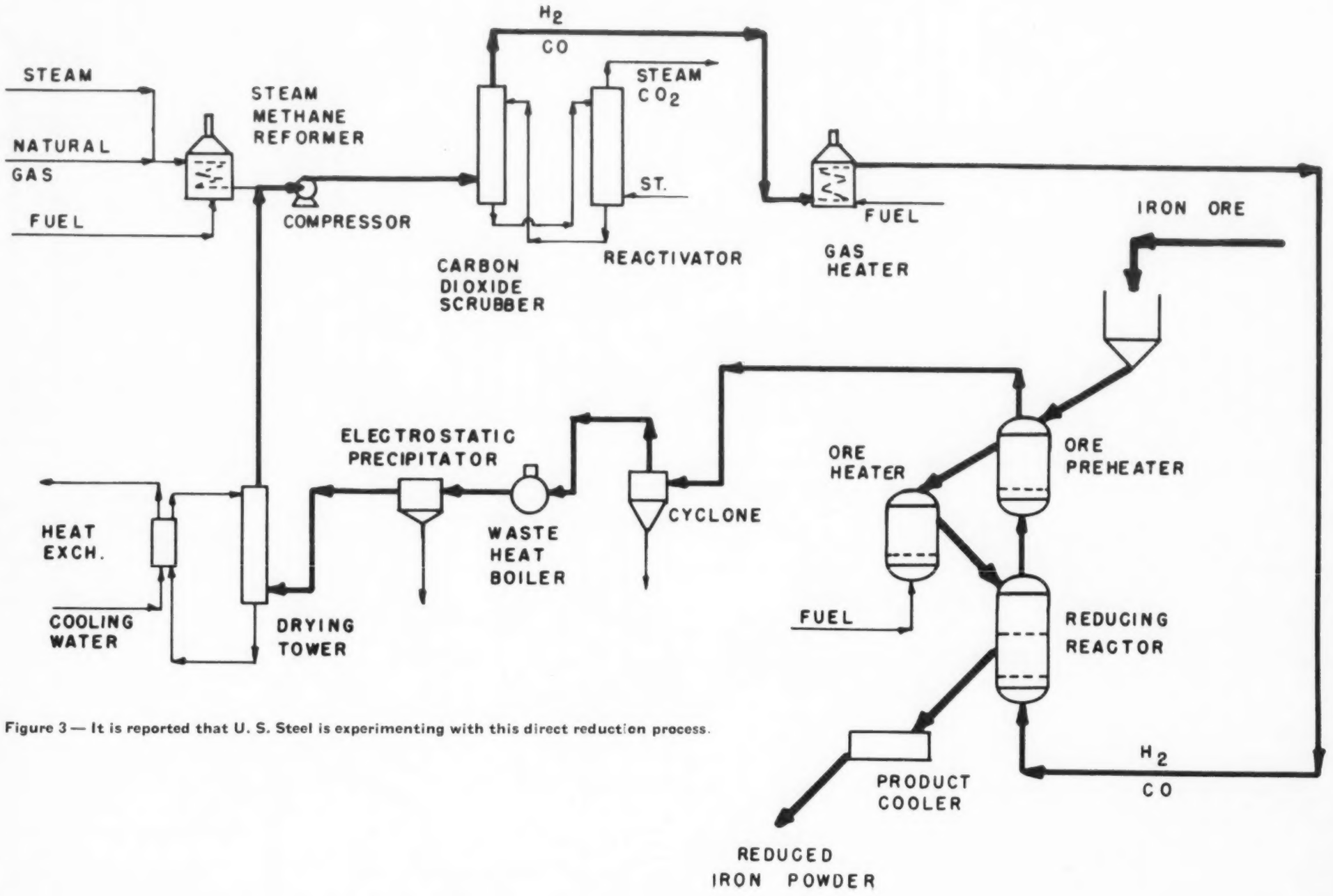


Figure 3 — It is reported that U. S. Steel is experimenting with this direct reduction process.

reduction of iron oxide to form a satisfactory commercial iron product for replacing hot metal or pig iron or even scrap as a steel melting furnace charge is not far away. As in all important developments, once the industry wide conditions indicate the new iron product to be economically highly desirable, it will be developed. The time may be not too far away when even the relatively small, more distant steel producer will become well integrated by putting a relatively simple and low cost iron ore reduction unit in one corner of the plant. This will have to provide him with the most economical charge for his melting furnace and the battle will be on between the scrap supplier and the ore salesman. The already operating larger tonnage steel plant using hot metal or cold pig iron will perhaps find it economically wise to most carefully investigate every detail of the new combination of an iron ore melting practice with its reduction by carbon to a high carbon, low silicon, low sulphur hot metal. Whatever develops, it is quite evident that the reduction of iron ore to produce either a molten product similar to blast furnace hot metal or a solid product similar to low carbon heavy melt steel scrap, has now reached the stage in this country where it is finally being reduced to practice. It is quite certain to require many months to determine what method or methods will be eventually adopted by the industry, but when the development finally approaches the point where it is adopted throughout the steel industry as standard, we will probably wonder what took it so long.

Many attempts have been made in the past to get around the high investment cost and serious limitations of the high tonnage blast furnace especially in Europe and it is interesting to speculate on the sometimes heartbreaking rejections some really good men have met with in trying to introduce an outstanding new development of an art to an industry which is not ready to receive it. This has been the case in the past with the steel industry and the direct reduction of iron ore was easy to postpone for another year. But today the continually increasing customers' pressure for improved quality in every product and the increasing evidence of better quality, cost and delivery in the competitors' product has resulted in the highest possible pressure for the development of new and better production equipment and practice. The extremely high investment cost of the blast furnace, open hearth combination has placed it very much on the defensive, and because of this high replacement cost, present operating equipment will be kept in operation just as long as it is at all commercially possible. This makes it difficult indeed for the engineer to come to a decision as to the best answer to the sales department's request for increased capacity. The electric arc furnace will try to meet this demand, but no one knows what the price of scrap would become if the demand for it were greatly increased as it surely would be if many tonnage electric furnaces were installed.

The answer must be a real development in a low cost iron ore reduction practice to provide the steel melting furnace and cupola with a material which will reduce in cost and stabilize the price of its main charge. It seems evident that such a development is now in the making, and all that is needed for it to be successful is an industry wide, highly interested concentration on the problem and an intense pressing demand for results.

Discussion

PRESENTED BY

STEPHEN VAJDA, Special Engineer, Steelmaking Office of Chief Engineer, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

HARRY W. McQUAID, Consulting Metallurgical Engineer, Cleveland, Ohio

Stephen Vajda: As the author points out, with the costs of new blast furnace and open hearth capacity going out of sight, a new approach must be found for the production of steel ingots.

Unfortunately, this approach is not as cut and dried as the need would seem to indicate. Not only is there a wide choice of different processes, but also several variations of each. The same answer will not hold for adjacent plants, let alone plants in different geographic areas.

These processes vary in scope and product produced:

1. One may remove only the oxygen from the ore and produce a solid end product in the form of an elongated briquette to be used as a substitute for scrap. H-iron is an example of this.
2. Another may produce hot liquid iron by the use of a chain grate or kiln and an electric smelting furnace. The DLM process by McDowell is an example of this.
3. Another may take finely ground ore and make a superior pellet suitable for a blast furnace charge. The ACL process by Allis-Chalmers is an example of this.
4. Still another makes steel direct by the melting of blown powdered iron ore with oxygen. The "Cyclosteel" process is an example of this.

The decision to which is the proper one will depend on the plant in question. In a completely integrated plant, one is interested in the process which will give the best burden for the blast furnace, open hearth or electric furnace. In a non-integrated plant, one should select the one which will furnish molten iron for the open hearth or electric furnace. And in a completely new plant, one will be interested in a layout which will replace not only the blast furnace, but also replace the open hearth with oxygen blown converters or electric furnaces.

Other variables which will effect the choice as to which process to use will be:

1. *Ore*—What analysis is it? Has beneficiation reduced it to a fine powder or is it comparatively coarse? A process which can use the coarse ore will be preferable to one requiring additional grinding.
2. *Fuel*—What type of fuel is available? What does it cost? An interesting process may prove uneconomical with high fuel costs.
3. *Coal*—What is the availability of coking coal? A surplus of coal will favor one over the other. Is coke breeze or regular coal available as a source of carbon?
4. *Scrap*—Is regular scrap available? What is its cost? Can the price be regulated by using a substitute?
5. *Steel*—What is the end product? What type of steel is required? One process will not answer all needs.

Finally, one has to overcome the conservatism of the operators themselves. With the amazing performance of a modern blast furnace with beneficiated ore, such as at Fairless, the incentive in integrated plants is diminished. It is cheaper to modernize and beneficiate. In a non-in-

tegrated plant, or even a new plant, one finds a reluctance on the part of the operators to accept a laboratory proven process despite the great capital savings. It takes a brave man indeed to authorize an expenditure of $15 to $20,000,000 for say a 1000-ton per day H-iron plant as a primary source of iron for a steelmaking facility.

Thus, although everyone agrees something has to be done, there is not much agreement on what this should be.

Harry W. McQuaid: The discussion by Mr. Vajda covers the present day uncertainty which confronts the management of any large steel plant when it comes to any important increase in ingot production. If the open hearth is to maintain its position as the leader in ingot production, something must be done to not only supply it with a proper charge material, but also if possible to have it in the liquid form corresponding to hot metal. In the cold solid form it imposes a definite production handicap as compared to liquid hot metal.

As things now exist, the blast furnace hot metal-open hearth combination is quite satisfactory and will only be changed to another set up which not only insures a satisfactory operation of the open hearth but a more economical over-all operation of the plant.

As things appear right now, the nearest approach to such a state of affairs would be the combination of a good commercial iron ore concentration plant with some preliminary deoxidation step like the Krupp-Renn process, and then the forming of this highly deoxidized product in combination with carbon as a briquette charged into a modern electric arc furnace. This is essentially the Republic-National Lead process and involves a considerable investment per annual ton of ingots. It also discards the high contained heat of the treated ore and mixed pulverized carbon as it leaves the kiln. It would seem to me just as logical to proceed the whole way from the deoxidizing kiln and use a properly applied oxygen enriched blast with natural gas or petroleum fuel to completely melt the ore-carbon mixture. It would not be difficult to reduce the molten iron ore-carbon mixture to a base for steel once it was completely molten. One process is now being developed whereby a very shallow bath of molten iron ore and pulverized carbon are intimately mixed under highly superheated conditions. Here the efficiency of the melting is relatively high and the deoxidation of the ore very fast and very complete.

As Mr. Vajda points out, there is no simple obvious way to select an iron ore direct reduction process which would be satisfactory under all conditions. However, if the primary problem was one of melting and superheating high grade iron ore concentrates under the best possible oxidizing conditions with the use of tonnage oxygen if necessary, the secondary problem of deoxidizing this superheated highly liquid molten iron ore with carbon in a convenient form would not be difficult.

In any case, the concentrations of our real study on the melting and superheating of iron oxide would soon establish the limitations of ore sizes, ore types, flux types, oxygen enrichment, fuel types, carbon forms and other factors controlling the basic economics of the direct ore reduction.

In any case the economics would be judged by the relative production cost of the final steel or iron as compared to the same product made from scrap or scrap-hot metal mixtures. Once the direct production costs are determined, the important factor in new production equipment will become the fixed charges per ton on the ingots resulting.

It is hard to see where the open hearth producer of high tonnage commercial grades of carbon steel from hot metal and scrap will be benefited very much by the adoption of a direct reduction process which is based on hydrogen, and which produces a cold solid charge which would be used to replace commercial scrap. In such a case the economic battle would be between commercial scrap and the direct reduced cold charge. It would serve to reduce the demand for purchased scrap and would probably be used as a threat to the scrap dealer, but in most cases the fight would be a losing one. The full commercial development of the hydrogen reduced ore concentrate will greatly help the economic position of the electric furnace ingot producer by putting some stability into his charge costs. ▲

1958 AISE

SPRING CONFERENCE

April 21, 22, 23

Tutwiler Hotel Birmingham, Ala.

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Monday, February 24, 1958—Dinner 6:30 P.M., Meeting 8:00 P.M.

"Design and Operation of Automatic Blast Furnace Stoves," by Walter N. Nielsen, Blast Furnace Superintendent, United States Pipe and Foundry Co., Birmingham, Ala.

Thomas Jefferson Hotel, Birmingham, Ala.

BUFFALO SECTION

Tuesday, February 11, 1958—Dinner 6:30 P.M., Meeting 8:00 P.M.

"Tackling The Problems of Water Pollution in The Steel Mill," by Everett Partridge, Director of Hall Laboratories, Pittsburgh, Pa.

Hotel Sheraton, Buffalo, N. Y.

CHICAGO SECTION

Tuesday, February 4, 1958—Dinner 6:15 P.M., Meeting 7:45 P.M.

"Maintenance Symposium"

"Shop Methods and Techniques Employed to Improve Equipment," by V. E. Holtslander, Assistant Superintendent Electrical Shops, Inland Steel Co., Indiana Harbor Works, East Chicago, Ind.

"Time Saving Gadgets for Merchant Mills," by J. Wysocke, General Electric Power Foreman, Wisconsin Steel Div., International Harvester Corp., Chicago, Ill.

"Modernizing Old Equipment," by J. Dobay, General Maintenance Foreman, Indiana Harbor Works, Youngstown Sheet & Tube Co., East Chicago, Ind.

Phil Smidt's Restaurant, 1205 N. Calumet Avenue, Hammond, Ind.

CLEVELAND SECTION

Data Not Available

DETROIT SECTION

Wednesday, February 12, 1958—Dinner 6:00 P.M., Meeting 8:00 P.M.

Detroit Edison Co. Night

Movie: "Achievement in Steel" Courtesy of Great Lakes Steel Corp., Div., National Steel Corp., Detroit, Mich.

"Influence of Gear Tooth Design on Lubrication," by E. S. Reynolds, Socony Mobil Oil Co. Inc., New York N. Y.

Dinner, Cafeteria, General Office Building Meeting, Sales Auditorium, Service Building, Detroit Edison Co., Detroit, Mich.

LOS ANGELES SECTION

No February Meeting.

PHILADELPHIA SECTION

Saturday, February 1, 1958—Dinner 6:00 P.M., Meeting 7:00 P.M.

"The Expansion Program at Sparrows Point"

"Engineering and Mechanical Aspects," by George C. Little, Assistant Superintendent, Mechanical Dept., Bethlehem Steel Co., Sparrows Point, Md.

"Electrical Aspects," by James M. Tillman, General Foreman, Power House, Electrical Dept., Bethlehem Steel Co., Sparrows Point, Md.

Engineers' Club, 1317 Spruce Street, Philadelphia, Pa.

PITTSBURGH SECTION

Monday, February 17, 1958—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Structural Design Problems and Recommended Practices for Ore Bridges and Unloaders," by W. B. McLean, Principal Structural Engineer, Engineering Works Div., Dravo Corp., Neville Island, Pittsburgh, Pa.

"When Do You Change Wire Rope Cables?" by J. E. Grimwood, Sales Representative, John A. Roebling's Sons Corp., Pittsburgh, Pa.

University Club, University Place, Pittsburgh, Pa.

ST. LOUIS SECTION

Wednesday, February 26, 1958—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Speaker and topic to be announced later.

Elks Club, Granite City, Ill.

SAN FRANCISCO SECTION

No February Meeting

UTAH SECTION

Monday, February 10, 1958—Social Hour 6:30 P.M., Dinner 7:30 P.M., Meeting 8:30 P.M.

"Mining Coal in Utah," by R. M. von Storch, General Superintendent Coal Mines and Quarries, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

Skyliner Cafe, Provo, Utah

YOUNGSTOWN SECTION

Monday, February 24, 1958—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Data not available.

Mahoning Country Club, Girard, Ohio

The Steel Industry of Mexico—

THE conquest of what is now Mexico by Hernán Cortés, took place more than 200 years before Pittsburgh was founded. The Spaniards did an excellent job of pinpointing deposits of gold, silver and lead and in getting their extraction into operation. However, the baser metals such as iron, were located but, very little attention paid to them. One finds throughout Mexico, small, low shaft charcoal furnaces always situated close to the iron deposits, with no attention ever been given to coal or coke. These furnaces served for the manufacture of material for colonial implements to the extent that this was permitted, because most of the manufactured products were coming from Europe under the doctrine of the colonial system.

Railroad construction by various American, British and French Companies, brought out for the first time the real necessity of coal and the only large and well explored deposits in Mexico, which start forty miles North of Monclova, were found and opened up because of the requirements of the railroads. Later, it was discovered that this coal, if properly selected, had good coking qualities, which permitted various British and American companies to think of modern lead and zinc refining operations in the Central and Northern part of Mexico. These companies, over the years, have grown to tremendous importance.

Somehow, little attention was given to the production of pig iron and steel in Mexico in commercial quantities until the turn of the century. At that time, the company which is now the Monterrey Steel Works (Compañia Fundidora de Fierro y Acero de Monterrey, S.A.) put up a blast furnace and steel plant, with rolling mills for rail and shapes. The usual growing pains of a new business in a new location were undoubtedly encountered but overcome, and by 1912 the Monterrey Steel Works was producing 60,000 tons per year. Then came the Mexican Revolution and all production of almost every kind came to a standstill, so that by the end of the revolutionary period, in 1918, the Monterrey Steel Works was only producing 20,000 tons per year. At the closing of this revolutionary period, began the renaissance of Mexican industrial activity.

The growth of the steel industry, by five year periods from this date on until 1940, is given as follows expressed in ingot tons per year:

1920	32,291
1925	81,136
1930	110,859
1935	121,278
1940	148,296

During this period Mexico was importing considerable quantities of steel in finished and fabricated form from the United States and Europe. Naturally, the several steel producers were interested in developing their production, but the problems that confronted them were probably such as to cause them to stop, look and listen.

1. The principal source of iron ore was close to the city of Durango, which is 394 miles from Monterrey (by rail) and 670 miles by rail from Mexico City, which is the principal steel consuming center in Mexico.

2. Little definite as yet was known about the coal reserves, although there had been and still were several good-sized mines, the largest and most modern of which was that of the American Smelting & Refining Company, in Rosita, Coahuila. Some "beehive" coke plants were in operation, or had been abandoned during the revolution, and were in such bad condition that rebuilding or repairs were not practical.

3. The railroads had suffered tremendously during this revolutionary period and were in the process of rehabilitation, a process which was made more difficult by the psychology of its operators coming out from a revolutionary period.

Therefore, in 1940, more thought was being given to

The Mexican steel industry is in the midst of a period of dynamic growth . . . . as in many other areas, one of the most difficult problems to be solved is the acquisition of the necessary capital.

by Ing. Pascual Gutiérrez Roldán, Managing Director
Altos Hornos de Mexico, S.A., Monclova, Coahuila, Mexico

its present and immediate future

the importation into Mexico of semi-finished steel products and scrap for remelting, rather than to the development of a basic Mexican steel industry. The lack of availability of large quantities of risk capital and investment capital, caused many of those who were beginning to recognize the necessity and possibilities of more steel consumption in the country, to turn towards the lower capital investment of conversion and finishing mills.

The Nacional Financiera, S.A., which is equivalent in Mexico to the "RFC" in the United States, became interested in the matter and recognized in short order the tremendous possibilities of Mexico as a basic steel-producing country. We did not know our iron ore reserves, and probably do not know them yet, although every year explorations and drillings of deposits that have been recognized for hundreds of years, are proving out many millions of tons more.

Outside of a very few persons, practically nothing was known about Mexican coal reserves, but their possibilities were present and these also, during the interum, have proven out to be sufficient in quality and quantity for long time programs of steel production and expansion.

The other items required, such as dolomite for metallurgical and refractory uses, were almost unknown. These, in the meantime have been found in sufficient qualities and quantities to at least partially fulfill the requirements, with good indications that there will be ample supply.

In other words, in 1940 the steel industry in Mexico was passing from its dormant state, and beginning to awaken to the possibilities of a brilliant future, using Mexican iron ore, coal and other raw products, combined with Mexican labor, to produce for the greater part that which the country requires in its program of industrialization and a better life for all.

RAW PRODUCTS

Iron ore—The present source of iron ore in Mexico (and during the past 50 years) has been "Cerro del Mercado" in the State of Durango. This tremendous deposit, which is a mountain of ore, is very close to the main railroad lines, quite the contrary to the case of most of the deposits which have been tested in the interum. It will average 60 per cent iron, 0.015 to 0.080 per cent sulphur and 0.400 to 0.800 per cent phosphorus. The known reserves here, in measured and indicated ore, amount to approximately 75,000,000 tons.

Right at the present time, a railroad is being built to the deposits known as "La Perla," which are 300 miles West of Monclova, Coahuila. This ore has the following analysis:

	Per cent
Iron	59.900
Sulphur	0.070
Phosphorous	0.130
Silica	6.000

Reserves in measured and indicated ore, over 40,000,000 tons.

Other explored and drilled deposits are the following:

"Las Truchas"	100,000,000 tons
"El Mamey"	150,000,000 tons
"Pihuamo"	4,000,000 tons

Over and above those named, there are many more known deposits distributed particularly throughout the Southern part of the country which give great hopes, once time and money have been put into them for exploration. The three deposits mentioned above need railroad transportation to make their ore available to the industry, but there is no doubt this will come as the requirements for more steel grows.

Coal—Coal has been discovered in a number of places in Mexico, but the only large and commercially exploitable area today is that known as the Sabinas Basin. Mexio is mining at present approximately 1,500,000 tons of coal per year, and preparations are being made to double this tonnage in the next several years. Fairly modern methods of mining are being used, with full face extraction and modern haulage systems. This coal, as it comes out of the ground, runs close to 35 per cent ash and rock. It is uneconomic to wash this coal to a lower ash content than 15.5 per cent which gives, in general, a coke with 80 per cent fixed carbon and 1 per cent volatile matter. Fortunately, this coke has very excellent physical characteristics, and when combined, in the blast furnace, with the hard, high grade iron ore that is available in very large quantities, gives an excellent pig iron at very reasonable costs.

Limestone—In the Northern part of Mexico there is no problem of limestone; the operating plants have good grade, low silica limestone available within several miles of their operations.

Dolomite—Although very little dolomite was being

extracted in Mexico until recently, good deposits have been found suitable for both metallurgical and refractory purposes.

Fluorspar—Northern Mexico is today one of the largest producing centers of fluorspar in the world and probably some Americans are using the metallurgical grade of spar in their plants.

Manganese—Manganese is produced all over the Central and Northern part of Mexico. As usual with manganese, the quality varies from mine to mine and in the same mine, and it must be beneficiated in practically all cases to make a suitable product, but there is no lack of this ore. However, there is less known about the possible reserves, principally because of the fact that its extraction is being handled, in general, by small miners.

Ferro-manganese—Mexico is also producing today its own ferro-manganese, using the better grades of ore for this purpose.

Fuel—Mexico is abundant in petroleum products. Where facilities exist, natural gas is being used by the industry and, in other cases, fuel oil transported by rail. Most of the Bunker "C" fuel oil has the disadvantage, however, of running from 3.5 to 4.5 per cent sulphur which causes quite an open hearth problem but which, like all other problems, had to be and was overcome.

Once having recognized that Mexico really had what was required to form the structure of a basic steel-producing community, the Nacional Financiera was instrumental in fomenting the organization of a new company, properly located, to take best advantage of known and accessible resources, the purpose of which company was to make products which Mexico was importing in ever-increasing quantities and which were not being produced in the country; namely, tinplate, deep-drawing sheets, enameling sheets, cold-rolled strip and all grades of light and heavy steel plate.

Table I shows the production, importation, total consumption, and consumption per capita of steel in Mexico, all expressed in ingot tons, from 1941 (the year in which Nacional Financiera decided to proceed with the construction of Altos Hornos de Mexico, S.A.) up to the present. To be brief, the author will only mention the following figures:

In 1941, Mexico produced 144,000 tons of steel ingots and imported steel to the extent of another 142,000 ingot tons, which made an apparent consumption of 286,000 tons, or 14 kilos (or 31 lb) of steel consumed per capita.

In 1956, Mexico produced 865,022 tons of steel ingots, imported steel products to the extent of 600,290 ingot tons, or a total apparent consumption of 1,465,312 tons, or a consumption per capita of 48 kilos (or 106 lbs). Taking into consideration that the consumption of steel per capita in the United States is 1400 lb per year, one can readily recognize that Mexico has a long way to go to reach the standard of living of the United States. However, the progression would seem to be of a geometric rather than of an arithmetic nature; Mexican people are no different from people of the United States in their wants and desires; more frequently than not, a man would rather own an automobile, a radio or a refrigerator than buy his own house.

The consumption of these products depends not on the desires of people but on the availability of credit; as credit systems develop so does installment-plan buying. Although someone said, facetiously, that "the installment-plan is a method for permitting a man to buy something he does not need, with money he does not have," it is certainly, when used within reasonable limits, a method of developing a better way of life, a more important industrial activity and, consequently, a greater steel industry.

Our economists have plotted curves considering national income and population increase, which would indicate that the ingot production of Mexico, by 1960, will be 1,460,000 tons and, in 1965, 2,000,000 tons. From our knowledge of what is going on in consumer plants, who have never as yet been able to satisfy the market, we believe that the economists are ultra-conservative. We believe the problem is not going to be one of using more steel, but of securing sufficient capital and putting up plants fast enough to take care of the requirements.

Appendix A lists the most important steel producers in Mexico, in the order of their importance as to tons of steel ingots produced in 1956, giving a brief summary of present equipment installed and of their plans for expansion for the next three years.

APPENDIX A

ALTOS HORNOS DE MEXICO, S.A.

Location
Monclova, Coahuila, Mexico.

Products offered for sale
Metallurgical and foundry coke.
Centrifugally-spun cast iron pipe.
All grades of plate, from 3/16 up to 3 in. thick, width up to 72 in.
Cold-reduced sheets for deep drawing, enameling and galvanizing.
Cold-rolled strip.
Tinplate.

Total 1956 production
Coke: 227,112 metric tons.
Pig iron: 205,787 metric tons.
Steel ingots: 314,172 metric tons.

Installed facilities

1. *Coke plant*
   114 Koppers-Essen retort ovens, complete with by-products section.
2. *Blast furnace*

	Height, ft-in.	Hearth diam., ft-in.	Bosh diam., ft-in.	Volume of stack, cu ft	Stove area, sq ft
"Guadalupe No. 1"	75-9	15-6	18-9¼	14,232	283,958
"Guadalupe No. 2"	84-6	21-0	24-5¾	28,129	474,918

   These furnaces are blown with three turboblowers as follows:
   No. 1 40,000 cfm at 25 psig—3,900 rpm
   No. 2 40,000 cfm at 30 psig—3,700 rpm
   No. 3 70,000 cfm at 30 psig—3,000 rpm
3. *Steel Department*
   3 Basic, stationary, open hearth furnaces, 110 metric ton capacity each. 1 basic, stationary, open hearth furnace, 120 metric ton capacity. Fuel used, Bunker "C" fuel oil.
4. *Rolling mills*
   Three 6-hole, soaking pits, 6 ft-9 in. x 15 ft-0 in. long x 11 ft-0 in. high. Fuel oil and coke oven gas.
   One 30-in. universal mill, 2-high, one-stand.
   One 24¾ in. & 46 in. x 48 in./84 in. 4-high one-stand, reversing plate and strip mill.
   One 34-in. cold reversing mill.
   Two 44-in. cold reversing mills.
   One 44-in. temper mill.
   Five hot dip tinning lines.

Under construction

1. "La Perla" mine development, to produce 3,000 metric tons per day of beneficiated, low phosphorous, 60 per cent iron content ore and the necessary 100 mine railroad to transport it.

2. Sintering plant, Greenawalt type, for producing 1,000 metric tons per day of blast furnace sinter.
3. Open hearths No. 5 and 6, 140 metric ton capacity each, complete with accessories.
4. Blooming mill, 40 x 96 in., for handling 12 metric ton ingots down to slabs for strip, plate and blooms.
5. One 16½ and 53 x 56-in., 4-high cold mill, reversing, with all accessories.
6. One gas turbine, 8100 kw to increase present installed capacity from 23,500 kva to 31,600 kva.

Plans for the immediate future

Installation of two more open hearths, 140 metric ton capacity each, along with a tandem 4-high hot mill incline with the present existing strip equipment, so as to approximately double the production of strip, increasing at the same time present maximum width of hot strip from 40 to 54 in. and a second 56-in. cold reversing sheet mill.

The above additions, which can be contemplated for completion by 1962, would increase Altos Hornos de Mexico's steel production capacity to 900,000 metric tons per year with sufficient finishing capacity behind it.

CIA. FUNDIDORA DE FIERRO Y ACERO DE MONTERREY, S.A.

Location

Monterrey, Nuevo Leon, Mexico.

Products manufactured

Structural shapes up to 15 in. high.
Rails up to 112 lb per yard.
Grinding rods.
Merchant bars.
Chilled cast iron car wheels.
Bolts and nuts.
Wire and wire products.
Fabricated steel, etc.

Total 1956 production

180,000 metric tons of steel ingots.
176,000 metric tons of pig iron and ferromanganese.

Installed facilities

1. *Blast furnaces*
   No. 1 daily present capacity: 350 metric tons.
   No. 2 daily present capacity: 550 metric tons.
2. *Open hearth* (straight hot metal and duplex operation)
   Five basic stationary open hearth furnaces with a rated capacity of 85 metric tons each.
   Fuel used: natural gas and fuel oil.
   Two 15-ton bessemer converters (acid lining).
   Two hot metal mixers: one 150-ton and one 300-ton capacity.
3. *Rolling mills*
   Three 6-hole soaking pits.
   One 40-in. blooming mill—high reversing mill.
   One 32/28-in. structural and rail mill.
   One 18-in. merchant mill.
   One combination rod, bar, light structural and skelp mill.
4. *Wire shop* (equipped for various kinds of wire).
5. *Bolt and nut shop* (hot and cold forged).
6. *Chilled cast iron car wheel foundry.*

Under construction

1. Two 250-metric ton open hearth furnaces.
2. Two 6-hole soaking pits.
3. 46 x 114-in. high-lift, blooming slabbing mill (capable of handling 20-ton ingots).
4. Cross-country billet mill.
5. Combination 5-stand plate and strip mill, and necessary auxiliary equipment for cold rolling.
6. 30,000-kw power plant.

These improvements shall increase capacity from 250,000 tons of steel ingots to 400 to 500,000 metric tons.

Plans for the immediate future

Third blast furnace—1,500 tons daily capacity.
Additional open hearths in the new shop being constructed.

These improvements shall increase capacity to around 750,000 tons, there being plans to increase blast furnace and open hearth capacity beyond this figure, with enough existing mill capacity to absorb it up to 1,500,000 tons.

LA CONSOLIDADA, S.A.

(Iron and Steel Division)

Location (3 plants)

I. Piedras Negras, Coahuila, Mexico.
II. Lecheria, Mexico, Mexico.
III. Mexico, D.F., Mexico.

Products offered for sale

Steel wire products, low and high carbon. Cold and hot forged nuts, bolts, nails, railroad spikes, etc.
Merchant mill products, reinforcing bar, etc.
Alloy steel flats and rounds.
Coil springs for freight cars, trucks, etc.
Common carbon and alloy steel ingots and billets.

Total 1956 production

Pig iron: 31,684 tons (8 months operation)
Steel ingots: 110,000 tons.
Steel finished products: 85,000 tons.

I. Piedras Negras

Installed facilities

1. *Blast furnace*

Height, ft-in.	Hearth diam, ft-in.	Bosh diam, ft-in.	Volume of stack, cu ft	Stove area, sq ft
73-1½	8-7½	11-10½	5,750	54,000

No. 1 blowing equipment—One reciprocating blowing engine delivering 12,000 cfm at 12 psig

2. *Steel department*
   1 basic, stationary, open hearth furnace, 50-metric ton capacity.
   1 basic, stationary, open hearth furnace, 75-metric ton capacity.

Under construction

1. One basic, stationary, open hearth furnace, 75-metric ton capacity.
2. One 132-pipe electrostatic precipitator for cleaning 21,500 cfm of gas.
3. One 33,000 cfhr steam turbine to generate steam at 400 psi 750 F.
4. One 1500-hp steam turbine.
5. One 25,000-cfm, 25 psig turboblower.
6. One railroad car repair shop.

Plans for the immediate future

1. Enlarging of blast furnace to cast 250 metric ton capacity daily.
2. Enlarging No. 1 open hearth furnace to tap 75 metric ton capacity daily.
3. Installing of ingot mold foundry.
4. Installing facilities for availability of bulk quantities of oxygen for usage in open hearth and blast furnace operation.

Upon completion of above mentioned installations the capacity of this plant will be of 180,000 tons per year.

II. Lecheria, Mexico

Installed facilities

One continuous, 50-metric tons per hr ingot heating furnace, equipped for burning either natural gas, diesel or fuel oil.
One 30-in., 3-high, one-stand breakdown mill.
One 24-in., 3-high, one-stand billet mill.
One continuous 23 metric tons per hr billet heating furnace, equipped for burning either fuel oil or diesel.
One 16-in., 3-high, two-stand mill.
One 16-in., 3-high one-stand mill.
One 14-in., 2-high, six stand mill.
One 10-in., 2-high, tandem six stand rod mill.

III. Mexico, D.F., Mexico

Installed facilities

1. *Steel department*
   One 4-metric ton electric furnace.
   One 6-metric ton electric furnace.
2. *Rolling mills*
   One continuous 10 metric ton per hr ingot heating furnace equipped for burning Bunker "C" fuel oil or diesel.
   One 3-high, 18-in. billet mill.
   One continuous 10 metric tons per hr billet reheating furnace equipped for burning either Bunker C fuel oil or diesel.
   One 16-in., 3-high, 2-stand mill.
   One 14-in., 3-high, 6-stand tandem rod and merchant mill.
3. *Steel wire mill department*
   Equipped with drawing machines, hot dip galvanizing line, wire annealing, etc.
4. *Nuts and bolts department*
   Equipped with cold and hot forging machines, and finished machines.

HOJALATA Y LAMINA, S.A.

Location

Monterrey, Nuevo León, Mexico.

Products offered for sale
Plate up to 42 in. width.
Hot rolled coils and sheets.
Cold rolled coils and sheets.
Tinplate.
Total 1956 production
118,724 metric tons of steel ingots.
Installed facilities
1. *Melting shop*
One 75-ton electric furnace.
One 32-ton electric furnace.
One 16-ton electric furnace.
One 8-ton electric furnace.
One 4-ton electric furnace.
2. *Rolling mills*
Six soaking pits, natural gas.
One 29 x 48-in., 2-high reversing universal mill.
One 25 and 46 x 48-in., 4-high hot steckel mill.
One 15 and 36 x 48-in., 4-high reversing cold mill.
One 12 and 28 x 48-in., 4-high temper mill.
One hot dip tinning line.
3. *Auxiliary equipment*
One cleaning line.
One pickling line.
Two 60-ton annealing furnaces.
Four 20-ton annealing furnaces.
Two shearing lines.
One slitting line.

Under construction
1. One 4-high reversing cold mill.
2. Four soaking pits.
3. One heavy gage shearing line.
4. One light gage shearing line.
5. One cleaning line.
6. Eight annealing furnaces.
7. One 75-ton electric furnace.

These additions will increase production to 200,000 tons of ingots.
Plans for the immediate future
One blooming mill.
One plate mill.
One tandem hot mill.
One tandem cold mill.
One continuous annealing furnace.
One continuous tinning line.
Production: 600,000 tons of ingots.

ACEROS ECATEPEC, S.A.

TALLERES SAN CRISTOBAL, S.A.

Location
San Cristobal Ecatepec, Estado de México, Mexico (on Km. 19½ of the Mexico-Pachuca Highway)
Products offered for sale
1. Rolled products of standard and high tensile steel.
a. Standard corrugated bar.
b. Cold torsioned high elastic limit "TOR" corrugated bar.
c. Foundry sub-products.
d. Rolling mill sub-products.
e. Structural steel flats.
f. Structural steel angles.
2. Structures and machinery.
a. Pushers.
b. Road oilers.
c. Grader's rolls and plows.
d. Flat and arch gates.
e. Scrap buckets and ingot cars.
f. Bridges, traveling cranes, transmission-line towers, substations.
g. Rolling machines, bar cold torsion machines and hoists.
h. Machinery and equipment repairs.

Total 1956 production
1. Rolling mill and foundry steel ingots: 35,860 tons.
2. Machinery (value in Mexican currency): $4,605,251.44.

Installed facilities
1. *Foundry*
Two arc furnaces, 10 to 12 metric tons capacity each, traveling crane, and complementary equipment.
2. *Rolling mills*
One 18-in. three-stand rolling mill complete with tables, one soaking ingot furnace, traveling crane, flying shears and all complementary equipment.
One 12-in. five-stand rolling mill complete with tables, soaking billet furnace, traveling saw, hoists and complementary equipment.
3. *Bar torsion machine*
Five bar cold torsion machines.
4. *Mechanical fabrication shops*
Lathes, rollers, welders, and all the machinery and equipment required for machine repairs and construction, as well as fabrication of equipment and structures.
5. *Expansion of laminating plant and metallic construction shops*
Work is under way to increase the output of the foundry and mills and a study is being made of the requirements of machinery and equipment for the addition of new lines of production, both in mill section and the fabrication shops.

These plans are estimated for completion in 1959.

ACEROS NACIONALES, S.A.

Location
Tlalnepantle, Estado de México, Mexico (10 miles from downtown Mexico City).
Products offered for sale
Steel and wire products.
High and low carbon steel wires of all types, including galvanized, electrode, spring steel, copper coated and various specialty wires.
Chains, twisted, welded and special for agriculture and ranch uses.
Barbed wire.
Machine and coach bolts and nuts.
Wood screws.
Nails and staples.
Hexagon and graduated fencing.
Total 1956 production
53,787 metric tons of steel ingots.
Installed facilities (all equipment purchased new).
1. *Melting division*
Two basic electric furnaces; one of 20 and one of 30-metric ton capacity.
2. *Rolling division*
One 3-high, 27-in. mill with tilting tables and continuous heating furnace.
One 3-high, 14-in. rod mill with continuous furnace.
One 2-high, 10-in. continuous mill to finish No. 5 rod.
3. *Wire division*
One 30-wire patenting line for spring steel wire.
Three galvanizing lines with a total of 100 wires with capacity to handle from No. 4 to No. 25 gage wire.
Fifty-four drawing machines with a total of 185 heads for drawing wires from ⅝ in. diam to No. 36 gage.
4. *Products division*
230 Machines producing all sizes and types of nails.
25 Machines producing machine and coach bolts from 1 to 6 in. in length.
97 Machines producing wood screws from ⅜ to 3 in. in length.
14 Machines producing twisted chain up to ¼ in. and welded chain up to ⅝ in.
9 Machines producing hexagon fencing from ½ to 2 in.

TABLE I
Apparent Production and Consumption of Steel Ingots
(Metric tons)

Year	Total production*	Imports**	Apparent consumption	Consumption per capita, kilograms
1941	144,084	142,008	286,092	14.07
1942	172,627	100,225	272,852	13.31
1943	166,012	165,227	331,239	15.47
1944	174,766	323,552	498,318	22.66
1945	229,993	314,210	544,203	24.11
1946	258,259	377,465	635,724	27.42
1947	290,688	433,665	724,353	30.42
1948	291,282	259,475	550,757	22.52
1949	370,669	264,827	635,496	25.29
1950	390,356	374,366	764,722	29.65
1951	466,683	637,563	1,104,246	41.61
1952	533,291	492,072	1,025,363	37.58
1953	525,030	322,996	848,026	30.23
1954	609,450	326,218	935,668	32.43
1955	725,350	335,869	1,061,219	35.80
1956	865,022	600,290	1,465,312	47.98

* This covers only steel ingot for rolling and does not include steel for casting.
** Covers importation of steel products (excluding scrap) converted to ingot on the basis of 1 = 1.33.

Discussion

PRESENTED BY

FLORENTINO MORAL, Metallurgical Engineer, Fundidora Veracruzana, S.A., Veracruz, Mexico

W. H. MATHESIUS, JR., Metallurgical Development and Process Engineer, Development Dept., Engineering and Construction Div., Koppers Co., Inc., Pittsburgh, Pa.

Florentino Moral: We have been invited by the Association of Iron and Steel Engineers to discuss this interesting document, presented by the top executive of the most progressive steel concern of Mexico, as well as the most important firm in our country, which was created only seventeen years ago. It is with great pleasure that we congratulate Mr. Gutiérrez Roldán, in the name of our Company, Fundidora Veracruzana, S.A., for having presented such a comprehensive report at this Convention, where many thousands of technicians and executives of the iron and steel industry of the United States and some other countries are very well represented through the Association of Iron and Steel Engineers, in this 50th anniversary of its founding.

Mexico is a growing country in permanent progress, in spite of many factors which are against its development, and the iron and steel industry of our country is going ahead without interruption. The new generations of engineers and technicians, the investors and men of enterprise, all of them are eager to find the right way to the national self-sufficiency in the field of the steel production, selecting and looking for more suitable operating techniques and methods of action through the aim of filling the increasing requirements of steel products.

As can be seen from the paper presented by Mr. Gutiérrez Roldán, the steel production of Mexico is about 1 per cent of that of the United States. The present level has been attained painfully, starting from a very low point, with a progression which is quite remarkable. Our country, however, is still importing a comparatively large tonnage of steel, from which two thirds are, roughly, finished products. The balance of the imports consists of primary and semifinished materials, such as ingots, billets, used rails and axles.

The steel plants mentioned in the paper constitute the vanguard of our permanent struggle for steel. They have a complement with a number of smaller concerns operating semi-integrated plants, and there are also not less than thirty other small plants operating rolling mills whose imports of used rails, axles and other rerolling materials are quite considerable.

In Mexico, it is common to have geographical scattering of small plants instead of the usual concentration of the steel industry as in many other countries. This spread is favored by the lack of integration of suitable capital investments, as well as the scarcity and high prices of the available means of transportation, and probably also by our individualism. This is not always a negative quality, as we have seen it is in many cases the spark for starting a number of industrial and commercial promotions and enterprises. The main fact is that those small plants play their role as a part of the whole which is the Mexican steel industry, and the total amount of their investments is quite important.

The yearly output of the small plants goes from 5,000 to 40,000 tons for each one, the average running from 10,000 to 12,000 tons. Almost all of them are in a position to increase their capacity and to improve their operations with adequate financing and long-term credit, which in most cases is scarce and very expensive. They would also need a suitable supply of steel ingots and billets for their rolling mills.

A certain number of the small semi-integrated plants are operating electric furnaces of small capacity, and only few of them are engaged in the production of steel castings. The majority of these small concerns are casting steel ingots for their rolling mills, with a great handicap in attempting to obtain reasonable costs, due to the fact that the electric power is scarce and also expensive in Mexico, as well as due to the small size of the electric furnaces. This does not apply to the large plants which operate more sizable electric furnaces, already mentioned in the paper.

One of the small plants of Mexico is that of Fundidora Veracruzana, S.A., located at Veracruz, a port on the Gulf of Mexico. This is a semi-integrated plant with a capacity of about 40,000 tons per year. The firm has been operating, and still operates one basic stationary, open hearth furnace of 40-ton capacity, and has now started operation of two acid, side-blown, bessemer converters with a capacity of 3.5 tons from each one. There are also two basic, hot blast, cupolas with carbon lining, having a capacity of 6 tons in each cupola, with continuous tapping. The temperature of the blast is about 1200 F, and 100 per cent steel scrap charge and furnace coke are being used. The running being continuous, operation of the cupolas is a new version of tiny blast furnaces; and to complete the resemblance, they are equipped with regenerators of refractory material, similar to blast furnace stoves, as well as water-cooled tuyeres of electrolitic copper, bustle pipes into the body and water sprays around the shell. All of these features, and a cyclone dust catcher between the stoves and the cupolas, were incorporated and made possible in Mexico, with Mexican design and Mexican labor, the only imported parts being the blowers.

The cupolas were first operated in March, 1956, and from that time they have proven to be a steady and suitable source of hot metal supply for the open hearth furnace and the two converters. The plant has been obtaining iron with a carbon content going from 3.2 up to 3.8 per cent, phosphorous under 0.030 and sulphur under 0.040 per cent.

The plant is making billet-size steel ingots. Its operation costs are low compared with those of cold charge open hearth furnaces, and of course much lower than those of the plants which operate electric furnaces. The described installation is proving to be very suitable, from the technical and economical point of view, for any small steel plant having a production of several thousand tons per month. The plant of Veracruz is being completed with a merchant rolling mill to produce reinforcing bars, a variety of commercial sections and light structurals.

There is a possibility of installing a number of small plants like that of Fundidora Veracruzana in several places of our country, to obtain scattered sources of ingots and billets and cover the urgent necessities of these materials for the existing non-integrated plants

and their rolling mills. With only ten plants like that of Veracruz, the national production of steel would be increased by 400,000 tons, this being a nice contribution going together, shoulder to shoulder, with the efforts and achievements of the big firms like Altos Hornos de Mexico and the other concerns mentioned in the paper. Taking again the reference to our capacity compared with that of the United States, with the ratio 1:100, the aforesaid expansion would mean a relative increase of 40,000,000 tons.

The increasing demand of steel products in Mexico is very far from being satisfied for many years ahead. It is a well known fact that the expansion of the steel production stimulates the creation and expansion of many other industries using steel, and Mexico is still importing a great variety of manufactured products in which steel is an important component or the whole composition of them. So the consumption per capita is much higher than that which is given by the figures showing only the production and imports of steel. We agree with the assertion of Mr. Gutiérrez Roldán that Mexico is able to reach the target of 2,000,000 tons of steel production long before 1965, and that the big problem is not that of finding the way to use and to consume more steel, but that of securing financial resources to install more and better steel plants, and also to expand the present facilities, fast enough to take care of the tremendous requirements imposed by the continuous progress of Mexico.

W. H. Mathesius, Jr.: The view that one can contemplate the future in Mexico, based upon the things that Senior Gutiérrez Roldán has told us, is nothing less than inspiring.

Moreover, the excellent review of the steel industry of Mexico at this meeting of the Association of Iron and Steel Engineers is a timely one. It fittingly calls attention to the bold and impressive plans of our friends in Mexico for expansion and improvement of their plants. Some people have probably felt, as hinted in the paper, that this flowering of basic industry was overdue in a land richly endowed, like the Republic of Mexico, with necessary mineral resources. The difficulties which have accounted for slow awakening may be, however, of less immediate interest to practical engineers than the fact that the republic now stands on the threshold of a potentially brillant industrial future.

Sr. Pascual Gutiérrez Roldán, has appended to his paper some extremely interesting tabulations of plant equipment, and with your permission we will refer to a few of the highlights in these tabulations, for the reason that Mexico is a land of contrasts. These contrasts also extend to the steel industry.

Thinking of the discussion which we have just heard of certain types of operations which are by no means unusual in Mexico, consider those operations for a moment and then behold the contrast with what is going to exist:

Compania Fundidora, in Monterrey—Under construction, two 250-metric ton open hearth furnaces; two open-hole soaking pits; 46 x 114 in. high-lift, blooming-slabbing mill capable of handling 20-ton ingots; cross-country billet mill; combination 5-stand plate and strip mill, and necessary auxiliary equipment for cold rolling.

Plans for the immediate future: Third blast furnace, 1500-ton daily capacity.

I am not slighting anyone here. I'm just taking the liberty of picking out some illustrative items.

Altos Hornos de Mexico—Open hearths Nos. 5 and 6, 140-metric-ton capacity each, complete with accessories; blooming mill, 40 x 96 in., for handling 12 metric-ton ingots down to slabs for strip, plate and blooms.

Plans for the immediate future: Two more open hearths, 140-metric-ton capacity each; tandem 4-high hot mill.

Hojalata y Lamina, Monterrey—Plans for the immediate future: one blooming mill, one plate mill, one tandem hot mill, one tandem cold mill, one continuous annealing furnace, one continuous tinning line.

A dramatic contrast this is between the small size and limited capacities of some of the present facilities, and the massive proportions and high production potentials of the facilities now being installed or planned for the near future.

I was particularly impressed with one sentence near the end of Sr. Roldán's printed text where he says:

> "We believe the problem is not going to be one of using more steel, but of securing sufficient capital and putting up plants fast enough to take care of the requirements."

When one is looking for capital—and in the steel business that is likely to mean that one is looking for considerable amounts—a thought which follows the idea of the need for capital is: How about the profits from the capital? How are these massive new facilities going to pay out?

We are not so naive as to believe that a machine is good merely because it is big. We have seen "white elephants" from time to time and we know that designing for high productive efficiency demands more than mere size. Nevertheless, when demand for output seems assured, we believe in general, rather firmly in big blast furnaces, big open hearths, big slabbing and blooming mills. If one asks why this is, the answer seems easy—big units are more efficient, they produce more cheaply than small units. But precisely why do they produce more cheaply? Again, the answer seems simple: they save labor and everybody knows that labor is expensive. But in places where labor seems to be not as expensive as capital, then where is the advantage? We might find this question less readily answered. Then suppose we make our question quite specific namely, if the purpose of buying expensive new equipment were only to save labor, might not the equipment cost be unjustified if labor is not expensive? Now if, on top of that, we put in rolling mills with annual capacities ranging up to 1,500,000 tons or more, of which we can use perhaps only a third or less, for a period of several years, where will we be then? Most engineers might say we would then be in a "hole."

Yet it appears that some of the fine, costly new equipment projected for installation in certain countries outside of the United States will operate for a considerable time at a fraction of capacity. How can this be done if capital equipment is more expensive than labor, especially if there should be the additional burden of paying part of the price in hard-won foreign exchange?

Thus it seems that the deceptively easy questions can

quickly lead to rather puzzling ones. Having wrestled with some of these myself, I have come to some tentative conclusions. Perhaps the most general sort of an answer is that the productivity of well-designed modern facilities, properly installed and operated, may be so vastly greater than that of obsolescent equipment that we do not always realize how tremendous the difference is.

Here we must make clear that we are speaking not only of labor productivity, but also of capital productivity and materials productivity, so that we consider not only man-hours per ton, but also the capital per unit of output and the materials used per unit of output. Nor is this the whole story; it is still only a part, because in the final analysis, figures of man-hours per ton really mean little unless they are multiplied by wage rates per hour so we get *labor cost* per ton of output. Moreover, even labor cost per ton does not tell us much unless we also know the capital costs, material costs and probably some overhead costs, so they can all be added to give the full cost. This means, for example, simply that high man-hours per ton may be no particular cost disadvantage if labor rates are correspondingly low, and that low labor costs per ton are no great advantage if capital costs per ton are correspondingly high. The point is, we cannot speak of low labor cost as a virtue in itself, or high capital cost as an evil, unless we know the sum total and the relationships between these cost factors. We must know, for example, how much labor saving we might buy with a certain capital investment, also whether there are any further savings to be had in materials or in overhead, and what the over-all result is likely to be.

Perhaps this sounds self-evident, or perhaps it sounds confusing. Whichever it seems, the subject is really pretty important and it can also be surprisingly complicated if one digs into it enough. Unfortunately, it is only too common to distort a given situation by over-simplification. For example, one of our current "bugaboos" is the high cost of capital equipment, which seems to worry us even more than the high cost of labor used to. We are alarmed that the dollars of equipment cost per ton of product seem to have increased more than the prices of steel products. But how about the *earning power* per dollar of investment in new equipment compared to that of obsolescent facilities? I am convinced that the inherent earning power of investment in good modern equipment, despite high investment cost, is generally considerably better than that of obsolescent equipment. It appears that the operating cost advantages of the new facilities over the old are great enough to make them economic even in cases where full utilization of their productive capacity may not be approached for some years.

Interestingly enough, one of the important operating cost advantages of modern steel plant equipment in some of the less highly industrialized countries turns out to be labor cost reduction, after all. The explanation for this, in certain cases, seems to be that labor is not so cheap as it may appear by simply comparing United States *labor pay rates* with others which may be relatively much lower. Partly, this is because the fringe and social benefit costs in other countries may be from double to even six or eight times as much, proportionately, as in the United States. Where fringe and social costs might be 15 per cent of the wages for a United States company, they can be as much as 100 per cent of wages, or even more, in other lands. In such cases, the social benefits provided for employees and their families are frequently very extensive and important and they are, of course, just as real a cost to the employer as the direct wages paid.

Finally, it is not unusual to find that the number of steel plant employees per unit of output for comparable products may be from two to five times as great in some countries as it is in the United States. This is due, of course, not only to differences in the efficiencies of the equipment, itself, but to various other factors as well, such as differences in quality or prices of materials, including energy sources, variations in plant layout and the ways in which traditions, customs or laws affect working arrangements. Frequently, the over-all effect of these circumstances is that the total labor *costs* to employers in countries where labor pay *rates* appear comparatively low may be approximately as great as United States labor costs.

In situations where relatively low labor pay rates give a superficial and false impression that labor costs are correspondingly low, actually the provision of facilities which permit substantial increases in labor productivity is not infrequently economic and desirable.

These are factors which in all likelihood contribute to the justification for the splendid new additions and replacements planned by the steel industry of Mexico. ▲

There is a constant demand for copies of "The Modern Strip Mill"

published by the Association of Iron and Steel Engineers.

If your copy is not in use please get in touch with us.

ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

The President's Message

In the twilight of our golden anniversary, we can see many landmarks of progress and achievement during the past fifty years, but we can be sure that the dawn of tomorrow will bring forth new problems and responsibilities to challenge the best efforts of our Association and the steel industry with which we are so intimately involved.

Contemplation of the future indicates a turbulent area of accelerated technical developments, stimulated by research. These developments will set up further problems in our economy and in human relations—problems that will call for a broadening of our activities and studies.

The officers and directors elected to serve the "Association of Iron and Steel Engineers" during 1958 appreciate the honor and responsibility you have bestowed. We need and solicit your wholehearted support in our efforts to creditably carry on our common objectives.

LEONARD LARSON

President, AISE

Leonard Larson

President 1958

Association of Iron and Steel Engineers

LEONARD LARSON was first employed as a draftsman at the Jones & Laughlin Steel Corp. and Carnegie Steel Corp. in Pittsburgh, Pa., from 1913 to 1917. During this period he attended night school at the Carnegie Institute of Technology. He moved to Massillon, Ohio, in 1917 as a draftsman for the Central Steel Co. and was appointed chief draftsman in 1918. When Central Alloy Steel Corp. was formed by the merger of Central Steel Co. and United Alloy Steel Corp. in 1926, he was appointed assistant chief engineer. In 1929 he was appointed chief engineer of Central Alloy Steel Corp. and retained this position also after Republic Steel Corp. merged with Central Alloy Steel Corp. In 1939 he was made chief engineer of the Cleveland district, Republic Steel Corp., the position he now holds. At various times in his career he has been on special assignments, especially in open hearth work and he also served for two years as division superintendent of the Massillon plant.

AISE Officers and Directors, 1958

EMIL KERN
First Vice-President

EMIL KERN was graduated from the University of Stuttgart, Germany, in 1926 and began his career as a machinist and designer with Mesta Machine Co. in 1930. He became associated with Reynolds Metals Co., as chief mechanical engineer in 1945, and joined the Allegheny Ludlum Steel Corp., Pittsburgh, Pa., as chief engineer the following year. In May, 1949, he was elected vice president in charge of engineering of the Allegheny Ludlum Steel Corp.

S. C. READ
Second Vice-President

S. C. READ attended Purdue University and the University of Michigan. He graduated from the University of Michigan with a degree in mechanical engineering, and later received a master's degree in metallurgical engineering at Carnegie Institute of Technology. Mr. Read started to work for Jones & Laughlin Steel Corp., Pittsburgh, Pa., in 1924 as assistant superintendent, power department at the South Side works. In 1938, he was made master mechanic of rolling mills, Pittsburgh works. He was appointed superintendent of blooming department and rolling mills, Pittsburgh works in March, 1946, and named manager of maintenance for the entire corporation in November, 1947. Mr. Read has since been made director, construction and maintenance for Jones & Laughlin Steel Corp.

C. E. PRITCHARD
Treasurer

C. E. PRITCHARD was born in Pittsburgh, Pa., and was graduated from Carnegie Institute of Technology in 1932. He first worked for the Atlantic Refining Co. where he stayed until 1937, at which time he entered the steel industry. He then became employed in mill maintenance at the Warren district of Republic Steel Corp., with later appointment as district lubrication engineer. In 1941 he was promoted to chief lubrication engineer of all Republic Steel's operations with headquarters in the general office in Cleveland. In 1951 he joined the Alan Wood Steel Co., serving as superintendent of finishing mills, and the following year was promoted to superintendent of mills, including all rolling mills and a cut nail mill, the position he now holds.

H. L. JENTER
Secretary

HARRY L. JENTER was born in Trenton, N. J. He joined the American Steel & Wire Division's Trenton works in 1917 as a draftsman, and for the next few years alternately worked for the division and attended college. In 1926 he was graduated from Syracuse University with a degree in mechanical engineering and transferred to the Cleveland office. In 1928 he was made assistant foreman at the Newburgh Wire Works. Mr. Jenter was transferred to the Cuyahoga works cold roll strip department in 1932, and in 1934 was made general foreman. He became assistant superintendent of the works in 1935, general superintendent in 1939, and in 1942 transferred to the headquarters office as assistant to the vice president of operations. He resumed the post of general superintendent of Cuyahoga works a year later, was made chief engineer in 1950, assistant district manager in 1952, and manager of operations Cleveland District, American Steel & Wire Division, U. S. Steel Corp., in 1953. In 1956, he became vice president of operations.

C. W. BRUCE
Director-at-Large

C. W. BRUCE was graduated from Case Institute of Technology in mechanical engineering in 1933. He started in the steel business in the blooming mill at the Corrigan-McKinney Steel Co., and in 1934 transferred to the combustion department. After the merger with Republic Steel Corp. in 1935, he continued in the combustion department until 1942, at which time he was transferred to the Chicago district of the Republic Steel Corp., as combustion engineer. In 1947 he was made assistant chief engineer of the Chicago district. In 1949 he was promoted to the position of chief engineer, Chicago district. He has just been named chief engineer, steel plants, Republic Steel Corp.

C. A. BAILEY
Director

CHARLES A. BAILEY was graduated in 1936 from the Ohio Northern University with a bachelor of science degree in mechanical engineering. He then entered the employment of the United States Steel Corp. at Gary, Ind., as practice engineer in the maintenance construction program of cold reduction mills and auxiliary equipment. In 1941 he was transferred to the research department as mechanical en-

gineer on pilot line electrolytic tinning equipment; from 1942 to 1945 he was lubricating engineer at Gary Steel Works; from 1945 to 1950 he was on special assignments on operating methods from the general superintendent's staff of Gary Steel Works. In 1950 he was assigned to the relocation and development of lubricants testing laboratory which is located in the research laboratory building of the National Tube Divisions, to provide services for all the divisions of the United States Steel Corp. He now occupies the position of lubrication engineer, National Tube Division, United States Steel Corp.

F. B. BEVELHEIMER
Director

F. BRUCE BEVELHEIMER started his steel career in the tin division of the Bethlehem Steel Co. at Sparrows Point in 1924. He later transferred to the fuel department as assistant combustion engineer. At the same time he attended night school at City College and Johns Hopkins University. In 1943 he moved to the Algoma Steel Corp. Ltd., at Sault Ste. Marie, where he worked as fuel engineer. He subsequently worked for two years at the Colorado Fuel and Iron Corp. at Buffalo as fuel engineer. In 1950, he moved to the steel division of the Ford Motor Co. where he was power and fuel engineer until January, 1957, when he joined Jones & Laughlin Steel Corp. as power and fuel engineer, on the staff of the chief engineer, the position which he now holds.

J. E. BODOH
Director

J. E. BODOH served from 1925 to 1929 as master mechanic for the Wisconsin Public Service Corp. at Green Bay, Wis.; from 1929 to 1952 as electrical engineer in charge of power distribution, signal systems, and d-c generating stations for the Illinois Terminal Railway System at Springfield, Ill.; and from 1935 to 1940 he served as substation and power generating station engineer for the Central Illinois Public Service Co., Springfield, Ill. In 1940 he entered the steel industry at the Gary Works United States Steel Corp. as electrical engineer, in 1942 he was made supervisor in charge of electrical design department, in 1945 he was promoted to assistant chief electrical engineer, and in 1946 was named to his present position of chief electrical engineer. Mr. Bodoh has been and is co-chairman of the AISE Crane Wiring Standards Committee.

H. B. BUCKINGHAM
Director

H. B. BUCKINGHAM was graduated from Mississippi State College in 1937 with a bachelor of science degree in electrical and mechanical engineering. He immediately entered the employ of the Tennessee Coal and Iron Div., of the United States Steel Corp., as a student engineer, since serving in various capacities at different works, until in 1952 he was appointed to his present position of electrical engineer of Raw Materials Div. of Tennessee Coal and Iron. He is a member of the American Institute of Mining and Metallurgical Engineers, president of Fairfield's Toastmasters Club, and a registered professional engineer, state of Alabama.

A. M. CAMERON
Director

A. M. CAMERON was born in Pictou County, Nova Scotia, and was educated at Carnegie Institute of Technology. He served his apprenticeship as a roll turner at the Nova Scotia Steel & Coal Co., and then moved to Crucible Steel Co. of America, Pittsburgh, Pa. He later worked as roll shop foreman at the Philadelphia Roll & Machine Co., and as roll designer at Atlas Steels, Ltd., Welland, Ontario. Mr. Cameron has since held positions of production planning, assistant superintendent of rolling and forging. In April, 1951, he was appointed superintendent of rolling mills and S. P. forge.

S. O. EVANS
Director

S. O. EVANS, a native of Wisconsin, was graduated in 1932 from the University of Wisconsin with a bachelor of science degree in electrical engineering, and one year later received a master of science degree in electrical engineering from the Iowa State College. He entered the employ of the General Electric Co. doing development work on transformers for five years. He then taught for the next five years at the Ohio State University. In 1944 he entered the employ of Babcock & Wilcox Company, serving successively as chief of engineering development, superintendent of extrusion, and finally in his present position as manager of tubing operations.

H. R. KNUST
Director

H. RUSSELL KNUST was born in Jessup, Md., in 1918. He was graduated from the University of Maryland with a Bachelor of Science degree in mechanical engineering in June 1940, when he entered the "loop" course of the Bethlehem Steel Company. In August 1940, he was transferred to the Sparrows point plant, mechanical department. At this plant he progressed from field foreman to assistant master mechanic of mills, to supervisor of maintenance, to assistant superintendent of mechanical department, superintendent of mechanical department, to assistant to general manager, and in 1956 he was appointed assistant general manager, the position he now holds. He is a member of the AISI, ASME and past president of the Engineers Club of Sparrows Point.

ALFRED KRAUSE
Director

ALFRED KRAUSE joined Ford Motor Co. as a follow-up man at the Ford Highland Park plant in January 1923. In 1928 he was transferred to the Rouge Plant steel rolling mills, in 1935 he became general foreman of the cold mill, and in 1937 he was promoted to shift superintendent of the rolling mill. During 1941 and 1942 he assisted in various wartime projects connected with the steel division. In 1945 he returned to the steel division as superintendent of open hearths, in 1946 he was named general superintendent of rolling mills, steel division, and in 1952 was appointed manager of the rolling mills, steel division, which position he now holds.

A. S. MERROW, JR.
Director

ARTHUR S. MERROW, JR., was born in Boston, Mass. He graduated from Tufts College in 1937 with a bachelor of science degree in chemical engineering. He began working as factory engineer in the filament and cathode department of the Hygrade Sylvania radio tube plant in Salem, Mass., later he joined the West Concord plant of the Ellis Chemical Co. He returned to school at the Massachusetts Institute of Technology and received a master of science degree in chemical engineering in 1939. He then entered the employ of the Bethlehem Steel Corp., Lackawanna plant, as an engineer, progressing through various departments to become senior engineer in charge of combustion work at the hot and cold strip mill, and the 10-in. and 12-in. bar mill divisions. In January, 1956 he was appointed to his present position of assistant fuel engineer.

P. W. PHENEGER
Director

PAUL WILLIAM PHENEGER was born in 1912. He graduated from Carnegie Institute of Technology with a bachelor of science degree in industrial engineering in 1934. From 1937 to 1945 he was employed with the National Supply Co., Spang Chalfant Div., Ambridge, Pa.; from 1945 until 1947 he was general superintendent, Michigan Seamless Tube Co., South Lyon, Mich.; from 1947 until 1956 he served as general superintendent, clad metal plant and assistant to the president, Superior Steel Corp., Carnegie, Pa. In 1956 he entered the employ of The Pollak Steel Co., Cincinnati, Ohio, as administrative vice president, which position he holds at the present time.

J. R. POWELL
Director

J. R. POWELL has been associated with the Jones & Laughlin Steel Corp. for a number of years. At the Aliquippa plant he advanced successively from general foreman of the by-product coke works to assistant superintendent, electrical department and then superintendent of the tin plate division. He was next assistant works manager at the Aliquippa works and then became assistant works manager of the Pittsburgh works. He is now works manager of the Cleveland works.

W. T. PURVANCE
Director

W. T. PURVANCE was born in Provo, Utah, in 1911 and attended Brigham Young University majoring in geology. He took extension courses in civil engineering from various universities and International Correspondence Schools. He is a licensed professional engineer. For several years he worked as resident construction engineer on bridges with the Utah State Road Commission, entering the services of Columbia Steel Co. Defense Plants Division as field engineer on construction of the Geneva works in 1942, later transferring to the Geneva Steel Co. as civil engineer. In 1946 he was appointed assistant chief engineer, and in 1952 became works engineer of Geneva works, Columbia-Geneva Steel Division, his present position.

W. D. REES
Director

W. D. REES was born in Girard, Ohio, and was graduated from the University of Pennsylvania with a bachelor of science degree in economics. During World War II, he served four years in the armed forces. He joined Sharon Steel in 1947 in the student training course. At present, he is superintendent of bar and blooming mill, Lowellville Works.

G. H. SCHAEFFER, JR.
Director

GEORGE H. SCHAEFFER, JR., was born in Reading, Pa., in 1919. He was graduated from Lehigh University in 1941 with a bachelor of science degree in electrical engineering, and entered the employ of the General Electric Co. In 1945, he joined Carpenter Steel Co. as assistant electrical engineer, and in 1947 he was appointed electrical engineer. In 1951, he became superintendent of electrical maintenance and engineering, the position he now holds. He also belongs to the SPE, AIEE, and IES.

A. W. SCHLECHTE
Director

A. W. SCHLECHTE was born in Michigan and attended high school in Granite City, Ill. Following an electrical apprentice course at Granite City Steel Co., he engaged in private business until 1937, when he rejoined Granite City Steel's electrical department. He was made foreman in 1941, assistant chief electrician in 1947, and chief electrical engineer in 1951.

E. C. THOMAS
Director

E. C. THOMAS, a native of Pennsylvania, started his steel career at Universal-Cyclops Steel Corp. in 1933. He worked up through various rolling mill positions to roll designer. During this period he attended night school at the Carnegie Institute of Technology, taking courses in mechanical engineering. He moved to Atlas Steels Ltd. as assistant roll mill superintendent. In January, 1948 he went to Jessop Steel Co. as rolling mill superintendent, eventually becoming general superintendent. In 1950 he moved to the west coast to go to work for Pacific States Steel Corp. at Niles, Calif.,

as works manager. In December, 1957 he was given the additional job of works manager of American Forge Co.

R. J. TREMBLAY
Director

R. J. TREMBLAY was graduated from the University of Washington in 1936 with a bachelor of science degree in mining and metallurgical engineering. He entered the employ of the Bethlehem Pacific Coast Steel Corp., Seattle plant, as combustion observer. In 1941 he was promoted to assistant to superintendent of rolling mills, Seattle plant, and in 1942 was named night superintendent. From 1944 to 1946 he was in the United States Navy and then returned to his former position. He was made assistant general manager of the Los Angeles plant in 1947, and in 1949 was promoted to general manager, his present position.

F. H. WICKLINE
Director

F. H. WICKLINE, a native of Columbus, Ohio, spent his youth in West Virginia. He received a bachelor of arts degree from Berea College, a bachelor of science in electrical engineering from West Virginia University, and also attended the executive graduate management course at the University of Pittsburgh. He first was employed as a test engineer with Duquesne Light Co., and in 1942 joined the United States Steel Corp. in the project engineering department, Homestead district works. In 1946 he was transferred to the construction engineering dept. of the National Tube division, Lorain, Ohio, in charge of electrical engineering for both the major expansions at the Lorain works and the Fairless works of the National Tube Div. In 1952 he was appointed electrical engineer for the entire National Tube Division, and in 1956 he was made assistant chief engineer of the National Tube division the position he presently holds.

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The Planetary Mill and its uses

by T. Sendzimir, The Sendzimir Co., Waterbury, Conn.

. . . . the planetary hot strip mill has demonstrated its advantages in certain applications . . . . its use in tandem with continuous casting is an interesting possibility . . . .

THE planetary mill is a more difficult mill in both theory and practice than the Sendzimir cold strip mill. There was more time consumed, more work, more expense, but the results are truly fascinating. Think of a 4 in. x 40 in. low carbon steel slab, heated to 300 degrees F under conventional rolling temperatures, entering the mill one after another at 70 tons per hr and being reduced to strip thickness on that one planetary mill stand alone, producing better gage accuracy from end to end and from side to side and a better surface.

Early discussions on the planetary mill invariably led to deep apprehensions. One apprehension was maintenance. Surely, such a mill would be subject to frequent breakdowns, the rolls and bearings would wear out rapidly, etc.—precisely the same objections heard in the early days of the Sendzimir cold strip mill. Today we hear them no more. Those who use these mills know they are the steadiest producers and maintenance is very low indeed.

On the planetary mill considerable progress has already been achieved and the least fear is a mechanical breakdown of the mill itself. There may still be trouble with coilers. A guide or a stripper may be missed but the mill itself just keeps going.

Planetary work rolls will reduce many hundreds of tons of good strip before they need regrinding, and thousands of tons of strip are rolled before either the backing rolls or the feed rolls are ground. Since there is only one stand to maintain, expenses per ton are quite reasonable.

Secondly, nearly every one thought that the planetary mill would produce a strip with a corrugated surface, a "washboard" effect. This will be discussed later in this paper but, of all problems, this is one that has never bothered us. The corrugations are small to begin with and are so easily removed in subsequent rolling that no one pays any attention to them now. Actually, a considerable amount of planetary mill strip is sold for use as hot rolled strip.

An explanation of the planetary mill may clear up possible misunderstandings. Planetary rolling is "cyclic" rolling or discontinuous rolling, where a roll first enters contact with the unworked portion of the material and then gradually works down, taking a rolling pass along the deformation zone and finally breaking contact with the material at the place where the material has reached its final thickness.

Figure 1 schematically represents the roll bite of a planetary mill. Two pairs of work rolls are shown, the first of which is close to the point where it shall leave contact with the strip and where the material is reduced to almost its finishing gage, whereas the second pair has just touched the slab at its initial thickness H and has penetrated deep enough to establish a full width of the deformation zone BA. The radius of the backing rolls is R_1, the radius of the work rolls is r and the circumscribed radius of the whole planetary assembly is R.

It will be seen that the work rolls have established this condition at an angle "a" from the vertical. The work rolls of course remain in rolling contact with the work piece throughout the roll bite. They also remain in rolling contact with their respective backing rolls and there is no slippage anywhere in the mill. Power is supplied by the backing rolls which turn the work rolls as well as propel them forward, by their frictional contact along the common generants such as G. For each pair of work rolls passing through the bite, the slab is fed by outside means (such as a pair of feed rolls not shown on this figure) by a small distance represented as "f" on this drawing. After reduction, this slab length is transformed into a length F of the strip which, depending upon the degree of reduction, may be 10, 20, 30 or even 50 times the distance f, since a 4-in. thick slab can be so reduced to 0.080 in., which is a 50 times extension.

This finished length of strip F represents the last portion of the contact of each pair of work rolls with the strip. Since these work rolls move on circular path and not along straight lines, the resulting portion of the strip F is bound to be somewhat concave although, by measurement, the concavity is much less than the geometrical relation because of the inevitable elasticity of the mill housing.

At the entry of the work rolls into the zone of plastic

deformation, Figure 1 shows in an exaggerated manner a front and back wave at the points B and A. The peculiar kneading action of the small planetary rolls plunging into the heavy slab produces certain effects known to slabbing mill operators but quite a bit exaggerated. As Prof. Trinks has put it, when a roll tends to penetrate into a plastically deformable material at high speed, the material momentarily escapes in the direction of the least resistance. In this case it means that a wave is produced on the surface both ahead and behind the work roll.

The back wave, as shown at A, is of a particular importance because it dislodges scale from the surface of the strip some distance back of the roll bite, so that it can be easily washed by sprays or even blown away.

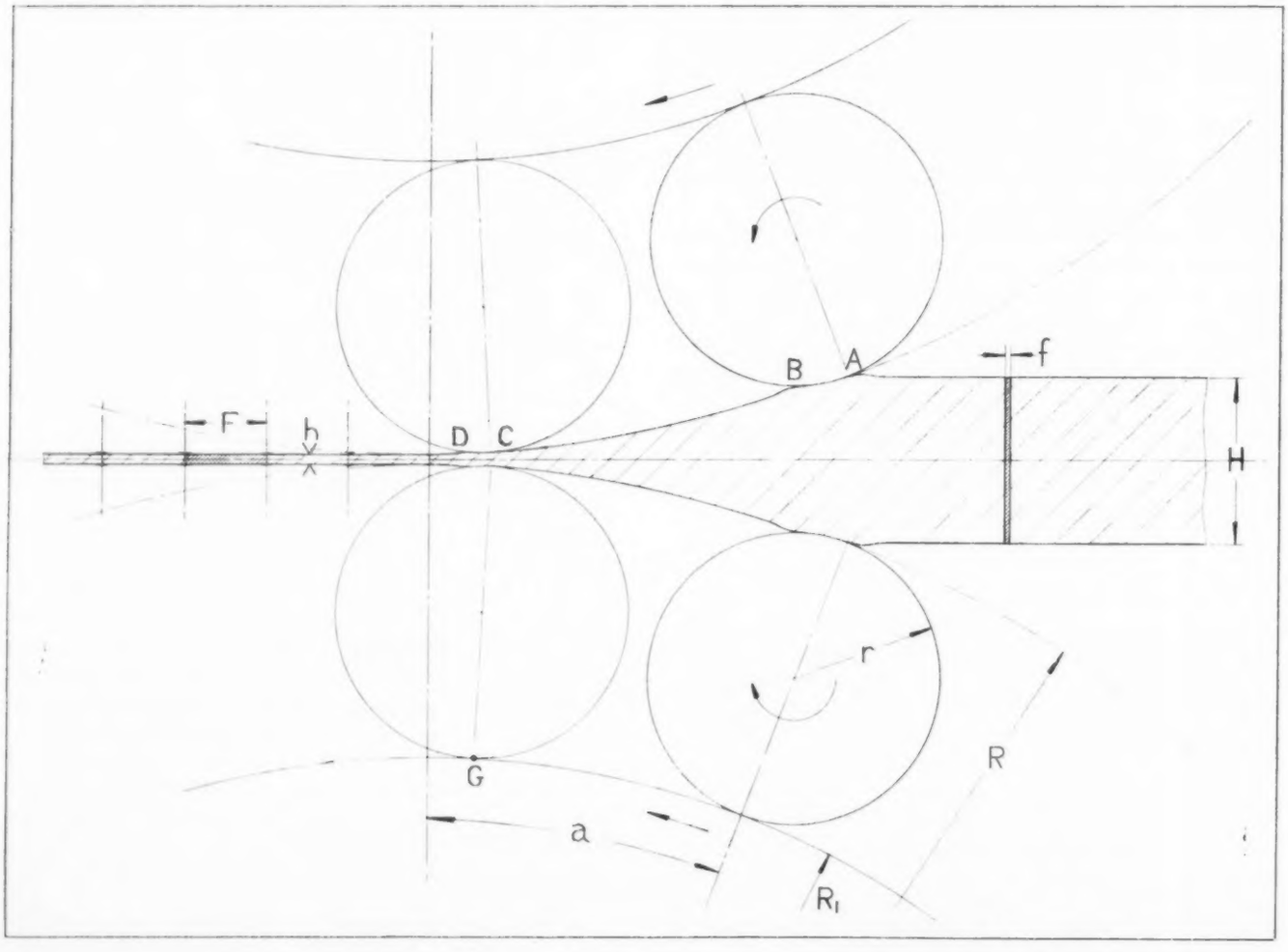
It is characteristic of the planetary mill that this wave is flattened out by rolling by the following pair of rolls, but only up to a certain maximum bite angle a mostly between 12 and 16 degrees. This condition depends upon the material, the diameter of the work rolls and upon the amount of f by which the slab is fed ahead for each pair of work rolls, but the designer of the planetary mill has to be conscious of this condition. Otherwise a back fin starts forming which might be rolled under and form slivers on the surface of the strip. If the bite angle a is further increased, that wave may reach the stage of becoming a complete and continuous back fin which is thrown back to the top and bottom work rolls at point A. This is possibly an ideal method of continuously scarfing the slab right in the planetary rolling operation and just ahead of the bite so as to produce the cleanest possible strip. We are experimenting along these lines, the chief problem being the continuous removal of these fins.

Figures 2 and 3 show complete planetary mills with their feeding means in a schematic manner. The backing rolls are shown as BR and work rolls as WR.

Figure 2 shows a pair of feed rolls marked FR taking a light pass on the slab S, the magnitude of which is determined chiefly by the necessary feeding force to be exerted in order to secure a safe forward movement of the slab. The feed rolls are disposed as close as practicable to the planetary assemblies so as to eliminate the danger of buckling of the slab between the feeding and the planetary mills. Water cooled guides T are disposed along this portion of the slab to insure satisfactory feeding operation when the first end of a slab butts against the last end of the preceding slab, thus securing a continuous operation of the planetary mill.

The planetary mill as shown in Figure 3 is for a discontinuous operation, each slab S being fed by a hydraulic ram actuated at a predetermined rate of speed by the cylinder C. Suitable guides T are provided to prevent buckling of the slab but rolling has to be stopped somewhat ahead of the point where the hydraulic ram could come in contact with the planetary

Figure 1 — Schematic sketch of planetary roll bite shows one pair of work rolls at the start of the bite, a second pair at the end.



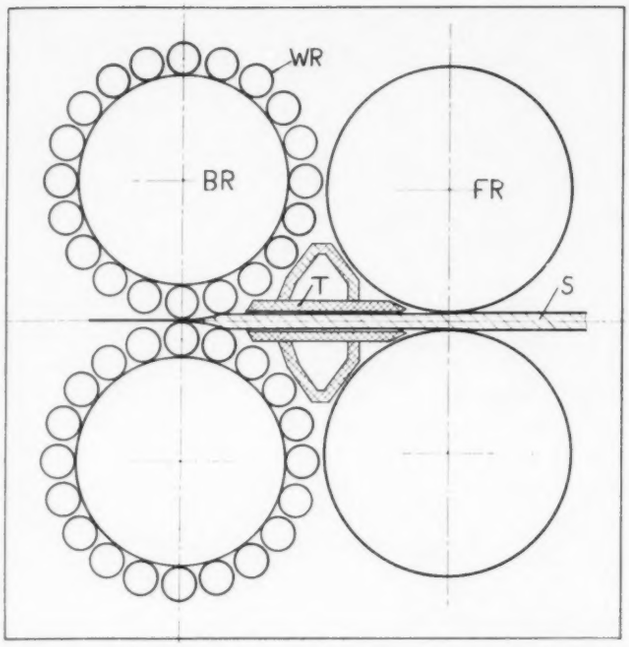


Figure 2 — Feed rolls take a light pass and push the slab through a water-cooled guide into the planetary rolls.

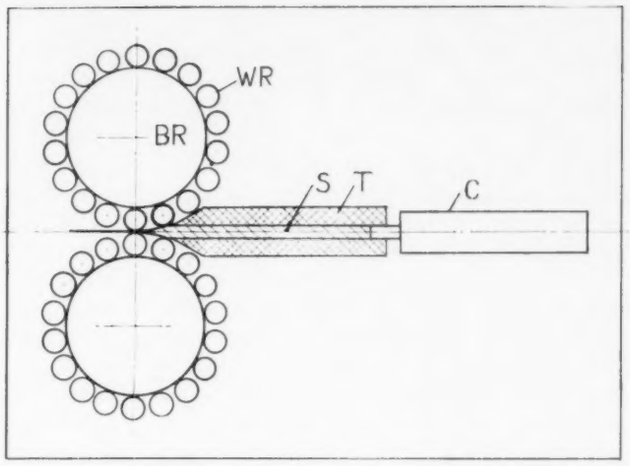


Figure 3 — If rolling is not continuous, with each slab pushing its predecessor, a hydraulic ram may be used to push each slab.

rolls and therefore a short portion of each slab has to be taken out only partly reduced.

The type of mill shown in Figure 3 might be used principally for experimental purposes or for reducing precious metals (titanium, zirconium, some magnetic materials, etc.), where each slab has to be separately heated, sometime in a special atmosphere furnace. In such cases, each slab may have a short piece of a mild steel dummy slab attached at the trailing end so as to reduce all the precious metal into a strip.

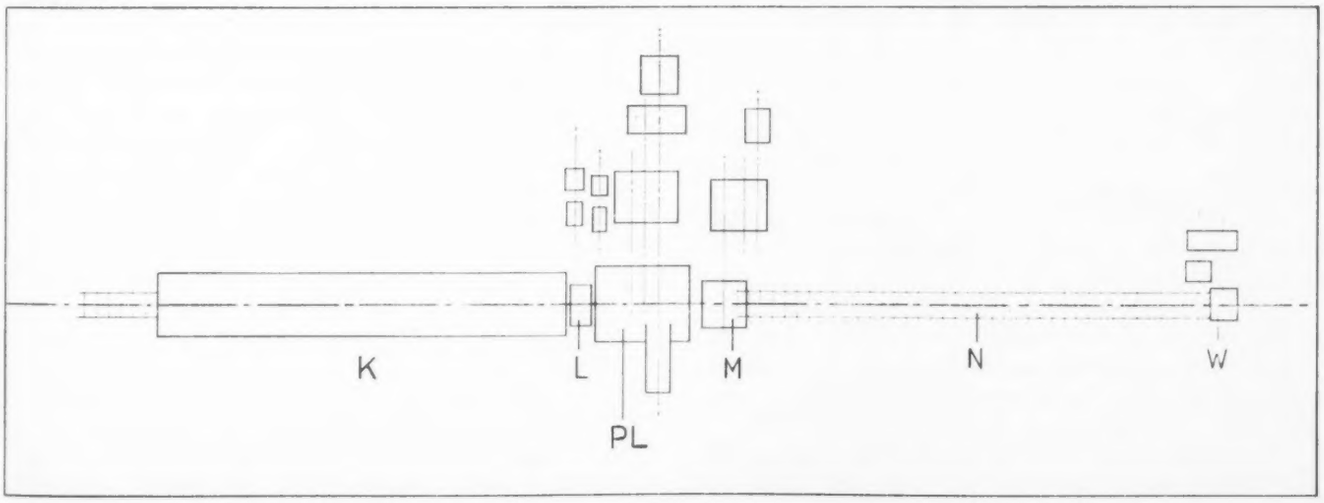
Figure 4 shows a layout of a complete planetary mill arranged for continuous operation, with slabs continuously fed one after another through the high heat exchange furnace K, a descaler L, the planetary mill consisting of a pair of feed rolls and the planetary itself, a planishing mill M, roller table N, and a coiler W, with their respective pinion stands, gear reducers and motors.

Figure 5 shows a layout of a planetary mill where slabs are heated in a conventional slab heating furnace as used on continuous mills, from which they are discharged on a roller table V, transferred to a descaler L and into the planetary mill PL, planishing mill M and coiler W. The corresponding pinion stands, gear reducer motors and motor generator sets as well as the operator's pulpits are also schematically shown.

The field of application of the planetary mill can best be deduced from the analysis of what happens in the deformation zone. The metal travels through the deformation zone quickly—usually from 1½ to 6 seconds in time and from 3 to 12 in. in length. This is only a small fraction of the large areas of hot metal exposed to atmosphere and other elements during rolling on either the continuous or the reversing hot strip mill.

While in the zone of plastic deformation, the metal is subject to two opposing effects, the relative influence of which, together with their magnitude, should be carefully evaluated. One is the temperature raise of the metal due to the energy of plastic deformation, which averages 40 kwhr per ton on steel and should be capable theoretically of increasing the temperature of the metal by several hundred degrees. At the same time, heat is rapidly abstracted from the surface of the metal within said zone by contact with the rapidly passing and relatively cold work rolls. Although the

Figure 4 — Layout of typical planetary mill, with high head furnace (K), descaler (L), planetary mill (PL) and planishing stand (M).



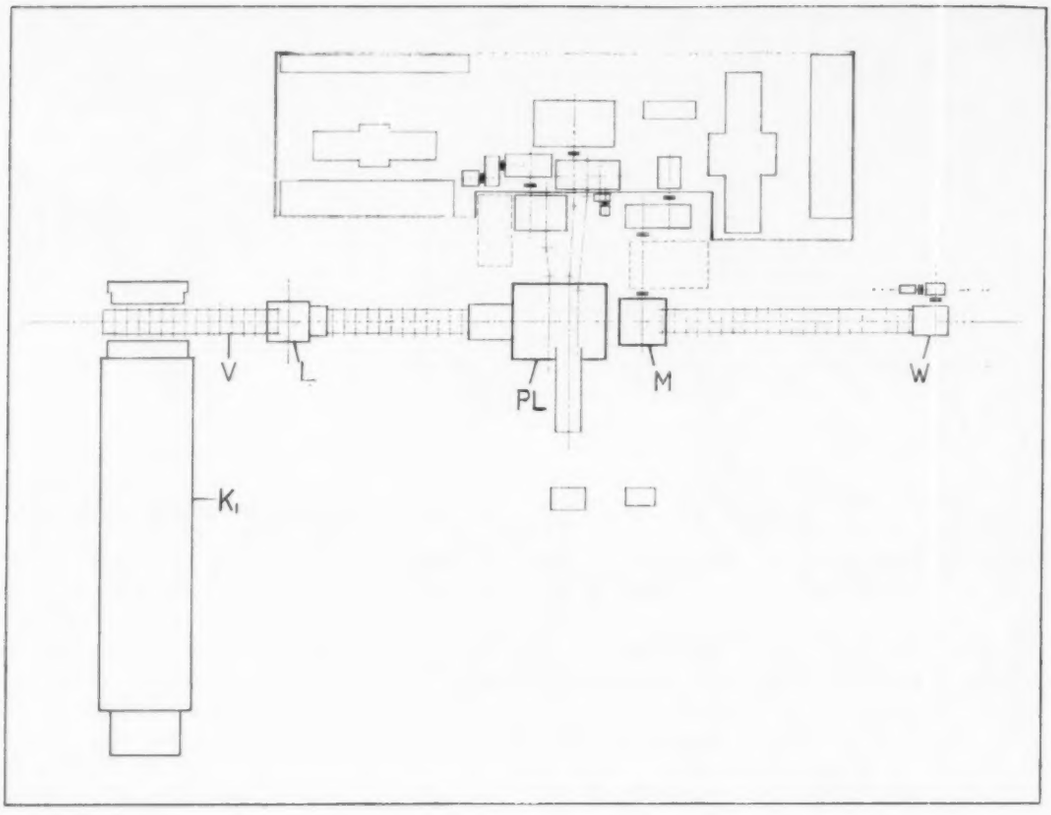


Figure 5 — This layout shows a planetary mill provided with a conventional slab furnace. An auxiliary equalizing furnace is usually needed just ahead of the mill.

length of contact by each work roll is of the order of $\frac{1}{1000}$ of a second, it is the very first contact that takes away most of the heat.

The mill designer, as well as the metallurgist and the mill operator, have now almost full liberty of choice as to what extent these two counteracting phenomena should be blended into each other. It is clear that the faster you feed the slab, the less heat will be abstracted by the work rolls and the less heat will be lost from the slab on its travel from the furnace to the mill. This would lead, as long as the speed of rotation of the planetary mill as well as the temperature of the slab is constant, to a higher temperature of the strip at exit of the planetary mill. This may or may not be desirable. Other parameters being equal, the higher the speed of rotation of the planetary mill, and the less metal advanced per cycle of each pair of planetary work rolls, the more heat will be abstracted from the roll bite and therefore the metal will be relatively cooler at exit. At the same time, of course, the length of the finished strip produced by each pair of rolls will be shorter and therefore, in some extreme cases of very light gage strip, the strip surface may look evener. That, however, is rarely an important factor, because even a noticeable "washboard" effect is easily corrected by the planishing mill used in tandem with the planetary mill.

Generally speaking, the strip temperature is higher at the exit from the planetary mill than the temperature of the slab at its entrance.

Hence the first obvious field of application for the planetary mill is the rolling of hard metals. If a metal resistant to plastic deformation at elevated temperature is to be rolled to light gages, it is obviously easier to arrive at a light gage if the planetary mill is so operated as to produce temperatures 100 or even 200 degrees higher at the exit, where the gage is lightest, than at entry end. Conventional mills are in most cases severely handicapped when rolling refractory metals because of the natural tendency of the metal to become gradually cooler as the rolling progresses, thereby increasing its resistance to plastic deformation. A report from a mill in England says that, when rolling 1½ in. x 8 in. low carbon and 18-8 stainless slabs to 0.080 in. in succession, the stainless steel came out only 0.002 in. heavier in gage than the low carbon steel.

Another obvious application is where scale is bothersome. Because of the feature of being able to increase the temperature during the progress of the metal through the roll bite, the metal can be heated to a relatively low temperature where scaling is light, and yet rolling can be completed at the desired finishing temperature. As mentioned, no large areas of metal are ever exposed to atmosphere at high temperature, for relatively long periods of time.

With a scale-free slab entering the mill, the short duration of the rolling process insures oxide-free strip exit. It is enough to prevent secondary oxidation by chilling or by a protective atmosphere to produce a strip clean enough for cold rolling without pickling.

If necessary, the slab in a planetary mill can be completely protected by a special atmosphere. The design of the planetary mill and the shortness of slab travel make that easy. Such protection might be against oxidation or against absorption of gases.

Since the planetary mill can be operated continuously, with the slabs being fed with one butting against another, and with the continuous high temperature head furnace located in tandem with the mill, the slab temperature can be kept constant within precise limits. With the heat input and output in the zone of plastic deformation being also constant, as previously mentioned, it is practical and easy to arrive at very close gage

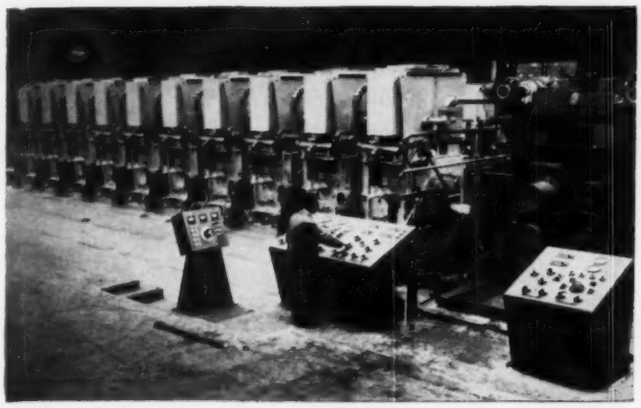


Figure 6 — This English installation uses a high temperature head furnace immediately ahead of the planetary mill.

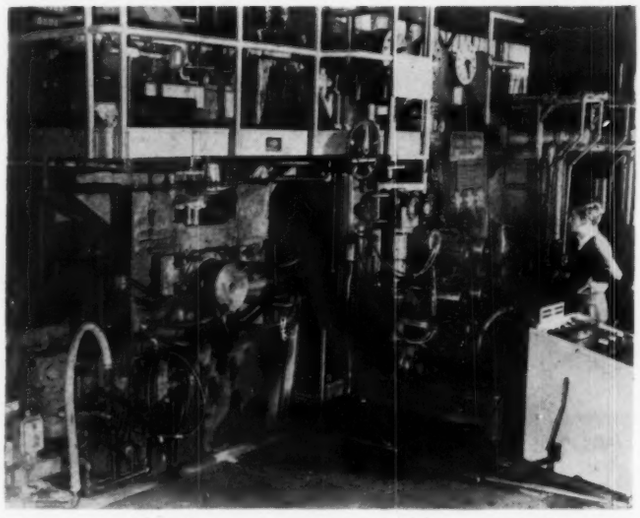


Figure 7 — This 24-in. planetary mill in Canada has two pairs of feed rolls ahead of the mill and a planishing stand following the mill.

control of the finished strip. In fact, at such gages as 0.100 in. down to 0.060 in. and lighter, cold rolling commercial tolerances can be maintained off of the hot mill.

Tunnel type high temperature head furnaces which are in most cases installed ahead of the planetary mill usually complete their heating cycle in less than 10 minutes. Wherever it may be desirable to shorten this cycle further, high frequency induction may be used either alone or after a preheat in another furnace.

Because of the relatively low rolling temperature and contact with cold rolls, the planetary strip has a good surface. Planetary work rolls are in contact with the metal for less than 0.001 second and each such contact is followed by a trip around the backing roll where the work roll is cooled by water sprays. Therefore, planetary work rolls are essentially cold rolls and are given a temper close to cold roll temper.

As a tool to produce hot rolled strip from slabs, the planetary mill must be considered in comparison with the continuous and semi-continuous hot strip mills as well as with the hot Steckel mill. Pricewise, it is by far the least expensive of the three. With finished gages around 0.080 in., its production at two tons or more per inch of width per hour is comparable to the hot Steckel mill. If used as a roughing mill in a continuous strip mill, it can produce over 300 tons per hr of 50 in. wide strip.

Acceptance of the planetary mill in small and medium widths, say up to 24 in. wide, will obviously be more for alloys than for low carbon steels. There are such applications where the use of it is clearly the best technical solution.

In the low carbon field, i.e., chiefly for strips 40 in. to 80 in. wide, one advantage of the planetary mill is the low installation cost. Operating costs are also low, since seven men can easily run a 40 in. mill including furnace, descaler and coiler.

The planetary mill can also be used as a breakdown stand in continuous mills, reducing 6 in. x 50 in. slabs to $\frac{1}{4}$ in. or $\frac{5}{16}$ in. to be finished on, say, three four-high finishing stands in tandem to a 0.080 in. hot rolled strip.

This combination deserves more than passing attention. It means a full continuous mill at the cost of one planetary mill and three finishing stands, but matches the production of a conventional continuous hot strip mill. Also, such a mill will give better gage tolerance and control, no limitation on coil weight and considerably less scale losses.

Progress with the planetary mill has an ally in the parallel progress in continuous casting. Continuously cast slabs are being sucessfully rolled on the planetary mill after some prior rolling on a slabbing mill. Experimentally, alloy steel slabs have been cast to planetary slab thickness ($2\frac{1}{2}$ in. x 17 in.) and rolled directly on the planetary mill with highly encouraging results.

A planetary mill is now being designed to be placed vertically and to take a cast slab as it comes down from the continuous casting machine in one continuous length. A flying shear located after the planetary mill would subdivide the hot rolled strip into coils of any weight desired. Judging by results known today of the continuous casting process and planetary techniques, an installation can be considered to cast 5 in. x 50 in. low carbon slabs at 120 tons per hr, following in tandem by a planetary stand and three finishing stands producing a 0.030 in. x 50 in. finished low carbon steel strip, ready for annealing and skin pass. The yield and operating costs of such a mill would be so favorable as to place it in a class by itself.

Discussion

PRESENTED BY

R. P. SCHULER, Superintendent, 76-In.-44-In. Hot Strip Mills and No. 3 Cold Strip Mill, Inland Steel Co., Indiana Harbor Works, East Chicago, Ind.

W. TRINKS, Associated Engineers, Inc., Pittsburgh, Pa.

FRED H. WUETIG, Manager, Fred H. Wuetig & Associates, Chicago, Ill.

R. M. REICHL, R. M. Reichl Co., Forest Hills, L. I., N. Y.

A. L. ROBERTS, Assistant Superintendent Sheet, Tin and Strip Mills, Bethlehem Steel Co., Sparrows Point, Md.

T. SENDZIMIR, The Sendzimir Co., Waterbury, Conn.

JAMES F. FOX, Sales Manager, Sendzimir Mill Div., The Waterbury Farrel Foundry & Machine Co., Waterbury, Conn.

R. P. Schuler: I have the following questions:

1. When the conventional type furnace is used as

was shown in Figure 5, isn't there a considerable temperature drop of the slab prior to rolling? With the slow entry speed into the planetary mill, there would be a large variation in temperature from head end to tail end of the piece being rolled. Is it necessary to have a tunnel furnace or holding furnace ahead of the mill in order to maintain proper slab temperature?

2. What is done with the piece of slab that remains between the pinch roll and the planetary mill when operations are shut down? Is the piece cut off on the delivery side of the planetary mill and the remaining piece backed out?

3. Mr. Sendzimir mentioned a set of guides located between the pinch rolls and the planetary mill. These are evidently located at this position to prevent the slab buckling due to the pushing effort of the pinch rolls. Have they encountered any scratches or rub marks from these guides and if so what was done to overcome them?

W. Trinks: I was consulted concerning the patent on Mr. Sendzimir's cold mill, and assisted in making his first cold mill in the United States work successfully. In those early days, Mr. Sendzimir mentioned his scheme of a planetary mill. At that time, I considered it to be a fantastic dream that had no chance of realization. Since those early days, both Mr. Sendzimir and I have learned a great deal. The planetary mill is a success if it is supplied with straight, properly sheared and uniformly heated slabs. It is the only continuous mill in existence, because successive slabs contact each other, and the strip emerges continuously without any interruption.

Several times I have had occasion to watch the planetary mill at the Atlas Steel Co. in operation. I recommend that anyone who has doubts about the successful operation of the planetary mill visit Atlas at Welland, Ontario, and be convinced.

Fred H. Wuetig: I am familiar with the original planetary installation made at Signode and at that time I understand that you had some problems in keeping the temperature in the steel during the slow rolling cycle. I wonder if that is entirely corrected. If I remember correctly, that was the most serious problem to be overcome and I imagine these high heat furnaces have probably contributed to that.

R. M. Reichl: I would like to ask whether the little planetary rolls don't have a non-uniform velocity; the geometry seems to indicate that these small planetary rolls change their velocity, and that also the ring in which they are located, undergoes periodic changes of angular velocity. I should also like to know whether I am correct in assuming that only one pair of rolls is in engagement at one time.

A. L. Roberts: I'd like Mr. Sendzimir to tell us something about the nature of the materials in these rolls and something about how long they might last.

T. Sendzimir: First, answering Mr. Schuler, I would comment that only on the widest planetary mill in Milan do we use a conventional slab furnace. That mill takes 3¾ in. thick by 40 in. wide slabs and rolls them to 0.100 in. at 70 metric tons per hour. There is an equalizing furnace installed just ahead of the mill and no trouble from cooler ends is experienced. The slabs are about 13 ft long and they keep the heat so well that there is no objectionable loss of temperature. The slab could be twice as long and we wouldn't have any trouble.

On the contrary, the other three continuous planetary mills use high heat head tunnel furnaces installed in line with the planetary mill where that problem is not present at all. This applies to the Ductile Mill and Habershon, as well as the mill at Atlas.

Answering Mr. Schuler's second question, it is true that the very last slab of the run is removed backwards after burning the strip off. Alternately, the rolls are lifted with a fast-working screwdown. The mill is capable of discharging the end portion of the slab in front. Of course, that is only the last slab end of the whole series of slabs, so there is little effect on the yield.

Answering the third question, I do not know of any wear on the guides between the feed rolls and the planetary rolls. They are set so that when the slab goes through it does not touch the guide. We have about an eighth of an inch clearance. But when the ends of the slab pass through, they seem to have a tendency of one end pushing the following one up, so the guides keep them in line. Therefore, the only time when the guide is subject to any scratching is just at the very end of the slab, and these short contacts have no appreciable effect on the guides. The guides themselves are faced with stellite and are internally water cooled.

Mr. Wuetig asked me about our first mill set up at Signode Steel Strapping Co. If I recall this situation, that mill had from the very beginning high temperature head furnaces installed in tandem. At first there were three furnaces and two more units have been added to make the heating faster and more uniform. I would like my associate, James F. Fox, who had a very intimate contact with that mill, to answer this question and also Mr. Roberts' question about various analyses of rolls.

I will only try to answer Dr. Reichl's question, although this one could lead us to a very long discussion, because there are certain parts of the theory of the planetary mill that are rather involved and even controversial. We are working hard on them and sometimes we still differ between ourselves as to what is actually happening and why it does happen. The fact is that by the pure geometry of it, the velocity of translation as well as the angular velocity of a planetary work roll as it spins around its axis has a tendency to gradually build up as the roll advances upon the roll bite but only by a very small fraction. The speed of the rings or cages that carry the rolls, does not vary because we provide a certain freedom in the bearings, permitting the roll to precede ahead of its former position; otherwise the speed of the cages would be varied as well.

But there are many other phenomena that enter. The fact is that they do vary, but even with the heaviest reductions—for instance, on the Ductile Steel's mill, reducing a 1½ in. slab to about 0.040 in., representing an elongation of 38, at a speed of operation of about 10 tons per hour on 15 in. wide strip—we have encountered no practical problems.

James F. Fox: The first question I shall deal with is that regarding the furnaces and heat loss in the slab between furnace and mill.

During our early experimental rolling we saw that relatively fast feeding and consequently faster heating was to be desired. On our prototype mill we started with two furnace units with a slab feeding rate of 18 in. per

min maximum, and added furnaces and increased the feeding rate in a series of steps until we could heat the slab to any temperature desired up to 2100 F at a rate of up to 60 in. per min. At this speed and with a 48 in. space between furnace and planetary roll bite we were able to maintain any temperature desired. With the heat generated in the planetary roll bite from the work energy of rolling we could, by varying the amounts of water contacting the work rolls and the material in the roll bite, control the temperature of the strip coming from the mill as desired, whether above that of the slab leaving the furnace or equal to it or below. This is an important point. It obviates the necessity of heating the slab to temperatures well above the desired finishing temperature, as is common practice in conventional hot mills. This feature not only affords a saving in fuel costs but also makes possible closer metallurgical control.

On larger mills, with greater spacing between the furnace and the planetary roll bite, feeding rates from 5 fpm up to 15 fpm are being used, depending on the thickness of slab, type of material, etc. In all these cases we are able to maintain the desired temperature at the planetary roll bite. The next question I should like to answer is that regarding the analysis of the planetary work rolls.

Our planetary work rolls have been made from hot worked die steel. All these have been of a type very close to the following typical percentage analysis: 0.4 C, 0.35 Mn, 5.0 Cr, 1.10 Si, 1.35 Mo, 0.9 Vn. This steel hardens up to $^{56}/_{58}$ Rockwell C and has good resistance to heat checking. It has been used for our purposes since it is possible, through power failure, etc., that the mill may stop with the hot slab momentarily tight in the roll bite. ▲

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RUSTPROOFING

THE prevention of rust on strip steel is a major problem in the finishing and shipping department of the strip mill. Rust can be prevented by coating steel with a protective coating of petroleum based rust preventives. The principal purpose of this paper will be to review the theory of rusting and corrosion and its prevention by the use of petroleum oils, and to discuss some specific problems and their remedies in this field.

The corrosion of steel depends on simultaneous contact with oxygen and liquid water. The initial phase of rusting actually amounts to the ionization of iron and water, whereby some of the iron enters the ionic state as it dissolves and exhibits *plus* electrical charges, thus displacing equal quantity of positively-charged hydrogen ions already present in water due to its ionization. The hydrogen assumes the gaseous state as it gives up its charges, and "plates out" on the surface of the parent iron to form a film that protects the iron against further solubility. The free oxygen present unites to form water and the protective film of hydrogen disappears. The chemistry of rusting is depicted by the following equations:

$$Fe + 2HOH = Fe(OH)_2 + H_2$$
(Soluble)

$$4Fe(OH)_2 + 2HOH + O_2 = 4Fe(OH)_3$$

$$2Fe(OH)_3 = Fe_2O_3 \cdot 3HOH \text{ (Insoluble)}$$

It might be further mentioned that corrosive effects of galvanic action in the presence of salts and the direct attack by acids are other sources of corrosion and these sources may co-exist with, and supplement, the corrosion due to water and oxygen. Furthermore, the speed of the attack is greatly accelerated by the presence of acids or acidic salts which provide a high concentration of hydrogen ion when dissolved in water. Salts in general, because of their ability to ionize in water, increase the electrolytic action and hence hasten rusting.

The only way corrosion can be prevented is by interposition of a barrier between the metal surface and air and water. In strip mill applications, the petroleum oil used to induce the barrier is commonly referred to as a slushing oil. Originally, the most readily available and cheapest of oils were used for this type of protection. It was gradually recognized that the best service was not obtained by selection of product in this manner. The amount of protection requirement increased, and in many cases the protective oil interfered with the proper functioning of the steel in further fabrication. It was found that in some cases the oil had to function as a lubricant. Easy removability was important in all applications; where long and severe exposure was encountered, ordinary oils were unsatisfactory.

These facts have led to the evolution of specialized rust preventives. Such products are specially designed for the particular jobs, considering the amount of protection required, lubrication requirements, appearance of the steel and any other requirements not associated with protection. Such products are far removed from the old "slushing compounds" which were, too often, anything handy.

The effectiveness of petroleum rust prevention depends, first of all, on their consistency. More viscous oils make a better barrier than those of low viscosity and petrolatums are more effective than oils. Bodying an oil with petrolatum improves its performance. A wide variety of slushing oils are available today, some of which are straight mineral oils, while others carry additives which aid in rust protection. Straight mineral oils for rust prevention range 85–250 sec Saybolt Universal Viscosity, and average about 100 sec at 100 F and are usually well refined lubricating oils. Especially adverse conditions may require special rust prevention products, which are chiefly oils of 35 to 250 sec at 100 F, carrying small amounts of fatty compounds, soaps, organic metallic compounds and mineral oil derivatives, etc. It may be of interest to note here that generally the chemical additives present in petroleum rust preventives are surface active agents. They can be divided into two groups, although some may show dual activity. The first group is active at the oil-water interface and the second at the oil-metal interface. Members of the first group lower the oil-water interfacial tensions and are essential in water-displacing characteristics. The action of the second group of surface-active compounds is of more general importance. These appear to be absorbed by metal surfaces to form a thin, but quite adherent coating. This coating is the principal barrier against corrosion. The overlying oil layer supplements its action and also acts as a reservoir of material to replace any that may be lost from the metal surface.

There are many factors influencing the proper selection of a petroleum rust preventive, the majority of which fall in the following category:

1. Exposure.
2. Nature of surface.
3. Handling.
4. Film Characteristics.

Since this paper deals mainly with the finishing and shipping departments of the strip mill, it can be readily seen that the slushing oils described will provide adequate protection where rust is a result of oxidation in the presence of moisture, and is due either to incomplete drying after an operation in which water is used or to condensation from the air. Other conditions have also been found to cause harm to sheet or strip surface, and a thorough study of the problem has shown some of these; and their remedies to be as set forth in Table I.

In conclusion, we might mention that in addition to the slushing oils described, the petroleum industry, in cooperation with the steel industry, has developed rust preventives which are used in preventive maintenance of equipment and building. The preservation of work rolls in storage, for example, is of great importance. If these rolls are not protected from the elements, the machined or ground roll surfaces soon rust and deteriorate. The preservative used should have the following properties:

by Eugene R. Slaby, Process Products Engineer, Socony Mobil Oil Co., Inc., Detroit, Mich.

OILS FOR PROCESSING

1. Should be fluid enough for air spray application under normal conditions.
2. A normal film thickness should dry fast enough not to run off.
3. Must provide complete protection to bright roll surfaces when the rolls are stored in the open for long periods of time.
4. Should preferably have a soft film, so that it will be self-healing.
5. Should be easily removed by quick swabbing with petroleum spirits.

Petrolatum base protective coating materials containing anti-rust agents have been found very effective in this application. These are supplied already reduced with volatile solvents to a consistency easily handled with the usual paint spraying equipment. When the solvent evaporates, a soft, non-drying film remains, which seals out air and moisture during prolonged storage in the open. The film is easily removed by wiping with mineral spirits.

TABLE I
Chart of Corrosion Causes and Remedies

Type of corrosion	Causes	Correction
Rust formation on bare spots	Incomplete drying of steel which has been in contact with moisture	Thorough drying before oiling. Use moisture displacing rust preventive
Faint film of rust over most of surface	Incomplete drying of steel which has been in contact with moisture	Thorough drying before oiling. Use moisture displacing rust preventive
Rusting in unidirectional streaks	Thin streaks of salt encountered in processing remain on steel	Thorough wash-off of all salts before drying and oiling
Heavy coating on outside of stacks	Condensation of moisture from air upon the steel sweating	Heat storage room. Prevent sudden temperature change. Keep metal warmer than surrounding air. Use special slushing oil. Spray stack with petrolatum
Finger marks	Perspiration from operators' hands	Wear cotton gloves. Use special rustproof oil
Splashes of rust	Water dripping on steel from overhead	Care in handling and storage
Pin marks	May arise from sheets touching pins in pickling racks	Use special rustproof oil
Yellow streaks or designs	Oxidation of fatty oils in slushing oils, giving a corrosive fatty acid	Select proper type of slushing oil
Gray cloudy corrosion with streaks	Mineral acid in slushing oil. Chlorinated compounds in oil	Eliminate source of acid. Select proper type of slushing oil
Rust marks after forming or processing	Moisture from emulsions used in processing	Dipping in hot slushing oil. Use of straight mineral oil or a richer soluble oil emulsion

Present day slushing oils when correctly applied to sheet or strip steel can effectively safeguard surfaces against rust and corrosion . . . . rust preventives permit shipment of coils without customary wrappings.

SUMMARY

Present day slushing oils correctly applied to sheet or strip steel effectively safeguard these surfaces against rust and corrosion. They are easy to apply, afford a certain degree of lubrication between metal layers during storage and shipment, and can be easily removed by petroleum solvents when desired. Recent developments in the packaging and shipment of strip coils has proven the effectiveness of modern petroleum rustproofing materials. Previously, all oiled coils were customarily wrapped with a greaseproof, waterproof and vaporproof paper before shipment. The recent developments in rust preventives permits the shipment of strip coils by rail, using only special coil hoods as the protection against the surrounding outside atmosphere.

From both the appearance and the economic viewpoints, rust is highly objectionable. Its unsightliness is irritating and its mere presence indicates financial loss.

Rust need not be tolerated since means exist by which it can be controlled. Scientifically designed petroleum rust preventives, correctly selected and properly applied provide advantages best measured in terms of:

1. Effective protection.
2. Ease of removal.
3. Maximum coverage.
4. Low in cost.

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PROGRAM

AISE Western Meeting

STATLER HOTEL LOS ANGELES, CALIFORNIA

February 24, 25, 26, 1958

MONDAY, FEBRUARY 24

8:30 am—REGISTRATION

9:00 am—TECHNICAL SESSION—SIERRA ROOM

Chairman: Ruben Finkelstein, Vice-President, Southwest Steel Rolling Mills, Inc., Los Angeles, Calif.

Louis E. Ringger, General Supervisor, Electrical Engineering, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

"Automatic Numerical Data Logging and Processing in the Steel Industry," by R. M. Sills and G. E. Terwilliger, Steel Mill Engineering, Systems Application Engineering Section, General Electric Co., Schenectady, N. Y.

"Static Control Provides Blast Furnace Automation," by Neal J. Behne, Electrical Engineer, Ohio Works, United States Steel Corp., Youngstown, Ohio; H. C. Diener, Jr., General Purpose Control Engineering Dept., Westinghouse Electric Corp., Buffalo, N. Y.; and J. Raymond Erbe, Metal Working Engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.

"A New Concept for Crane Control," by Charles H. Zweifel, Chief Engineer, Pacific Coast Engineering Co., Alameda, Calif.

2:00 pm—TECHNICAL SESSION—Sierra Room

Chairmen: W. E. Harris, Plant Engineer, Consolidated Western Steel Div., United States Steel Corp., Provo, Utah

W. H. Kinney, Assistant to Vice President of Operations, Kaiser Steel Corp., Oakland, Calif.

"Allegheny Ludlum Steel Corp.'s New Forge Shop, Dunkirk, N. Y.," by Emil Kern, Vice President in Charge of Engineering, Allegheny Ludlum Steel Corp., Brackenridge, Pa., and James E. Trabits, Plant Engineer, Allegheny Ludlum Steel Corp., Dunkirk, N. Y.

"A Modern Forging Press and Its Control," by Otto Hoffmann, Vice President—Engineering, and Alex Krynytzky, Supervisor, Mechanical Engineering, Lake Erie Machinery Corp., Buffalo, N. Y.

"Some Heavy Industrial Noise Problems, Their Analyses and Solutions," by Richard D. Lemmerman, Manager, and Richard R. Audette, Assistant Chief Engineer, Industrial Sound Control Dept., Koppers Co., Inc., Baltimore, Md.

RUBEN FINKELSTEIN

L. E. RINGGER

W. E. HARRIS

W. H. KINNEY

"**Ten Painting 'Reminders' for Steel Plants,**" by Walter T. Yarhouse, Industrial Sales Representative, The Sherwin-Williams Co., Cleveland, Ohio

TUESDAY, FEBRUARY 25

9:00 am—TECHNICAL SESSION— Sierra Room

Chairmen: G. W. Teskey, Jr., Superintendent Open Hearth, Bethlehem Pacific Coast Steel Corp., San Francisco, Calif.

Ernest F. Donatic, General Superintendent, Kaiser Steel Corp., Fontana, Calif.

"**Immersion Thermocouple Practice,**" by H. V. Schubert, Fuel Engineer, Seattle Plant, Bethlehem Pacific Coast Steel Corp., Seattle, Wash.

"**Continuous Annealing 60 Tons per Hour of Tinplate,**" by Quentin M. Bloom, Manager, Furnace and Kiln Div., Selas Corporation of America, Dresher, Pa.

"**Safeguarding Steel Production,**" by R. M. L. Russell, Assistant Chief Engineer, Factory Insurance Association, Hartford, Conn.

2:00 pm—TECHNICAL SESSION— Sierra Room

Chairmen: William Brill, Director of Engineering, The Colorado Fuel and Iron Corp., Pueblo, Colo.

R. L. Dowell, Assistant to General Superintendent, Columbia-Geneva Steel Div., United States Steel Corp., Pittsburg, Calif.

"**Thermit Welding Structural Mill Rolls,**" by Edward B. Russell, Assistant to Superintendent, Mechanical Shops, Kaiser Steel Corp., Fontana, Calif.

"**Electrical Equipment for a Modern Sheet Temper Mill,**" by D. E. Rea, Application Engineer, Electrical Application Dept., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

"**Rolling of Metals,**" by Joseph I. Greenberger, Group Engineer, United Engineering and Foundry Co., Pittsburgh, Pa.

"**Mechanical Maintenance at the Pueblo Plant of The Colorado Fuel and Iron Corporation,**" by Jerome L. Lindberg, Assistant to the Director of Mechanical Maintenance, The Colorado Fuel and Iron Corp., Pueblo, Colo.

7:00 pm—INFORMAL STAG DINNER— Pacific Ball Room

WEDNESDAY, FEBRUARY 26

8:30 am

Inspection Trip to Harvey Aluminum Co. and Harvey Machine Co. Buses leave from Hotel Statler.

hotel reservations

Write direct for hotel reservations to Hotel Statler, Los Angeles, Calif., giving time of arrival and type of accommodations desired. Reservations should state that they are for AISE Western Meeting.

transportation

Individuals or groups desiring assistance in planning their trip should get in touch with the office of American Express Company in their respective cities, or with any local travel agency.

G. W. TESKEY, JR.

E. F. DONATIC

WILLIAM BRILL

R. L. DOWELL

Abstracts of Technical Papers

to be presented at

AISE Western Meeting

February 24, 25, 26, 1958

Statler Hotel, Los Angeles, Calif.

"AUTOMATIC NUMERICAL DATA LOGGING AND PROCESSING IN THE STEEL INDUSTRY"

by R. M. SILLS and G. E. TERWILLIGER, Steel Mill Engineering, Systems Application Engineering Section, General Electric Co., Schenectady, N. Y.

R. M. SILLS

△ THE paper discusses the need for and uses of data logging and processing in the steel industry. Since this is probably a new field for many steel mill men, some of the more frequently met terms are defined, including a discussion of numerical or digital codes often used, and the advantages of digital systems.

The paper then goes on to describe the principles, construction and uses of many of the devices or "hardware" used in this field, such as analog-digital converters, storage devices and scanners.

With this background, some actual systems are described, with emphasis on the reasons for using them and the benefits expected to be gained. Systems included are those for a tandem cold mill and for an electrolytic tinning line. Extension of these or similar systems to other steel mill processes is discussed.

G. E. TERWILLIGER

The paper concludes with a review of the benefits to be gained by installing data processing equipment, a discussion of the trends to be thinking about for the not-so-distant future, and some of the factors that may tend to hold back the rapid advancement of this new tool of automation.

"STATIC CONTROL PROVIDES BLAST FURNACE AUTOMATION"

by NEAL J. BEHNE, Electrical Engineer, Ohio Works, United States Steel Corp., Youngstown, Ohio; H. C. DIENER, JR., General Purpose Control Engineering Dept., Westinghouse Electric Corp., Buffalo, N. Y.; and J. RAYMOND ERBE, Metal Working Engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.

H. C. DIENER, JR.

J. R. ERBE

△ THE authors plan to cover in this paper some of the problems encountered in operating a blast furnace and what can be done to reduce them.

The paper presents some of the factors influencing the decision to automate the operation of these furnaces and to what extent their automation was carried at this time.

The merits of static control are compared with other types of control systems. The theory, design and functioning of the static control used in this application are discussed.

Operating and test data are presented which was obtained from this installation during its initial testing and start-up.

The advantages gained by the

use of static control for this application are described as well as possibilities for further automation for future installations.

The paper also discusses the use of static control for other applications within the steel industry and points out some of the advantages to be gained by automating other processes or functions.

"A NEW CONCEPT FOR CRANE CONTROL"

by C. H. ZWEIFEL, Chief Engineer, Pacific Coast Engineering Co., Alameda, Calif.

C. H. ZWEIFEL

△ OUR company, being principally engaged in the design and fabrication of cranes for all types of installations, has felt for some time that commercially available crane control systems were lacking functional operating features required by users of this equipment. We approach the problem from the standpoint of the user, keeping in mind: the functional requirements; the first cost, the maintenance and the type of crane components with which operating personnel are familiar. Combining our knowledge with specialists in the field of rotating equipment, as well as specialists in crane control equipment, we have developed the multi-range hoist.

The multi-range system has the following basic features:

1. The system can be powered from either a prime a-c or d-c source, making the system adaptable to any existing installation with hoist operating characteristics of the basic Ward Leonard d-c dynamic system, modified with magnetic amplifier voltage control.

2. The system provides both heavy hook capacity, low speed operation, as well as light hook capacity high speed operation. The versatility of this scheme permits spotting of the empty hook or handling of light loads at high speeds and immediately when required switching over to the stable low speed handling characteristics when required by the job at hand. This results in increased crane production and substantial time savings in crane operation.

3. The system eliminates one complete set of hoisting equipment as well as motor and control equipment on those cranes which require two hoists. Current designs are limited to a load range of 5 to 1 between the heavy hook and the light hook, with maximum speed range of 1 to 4. For example, the crane can be designed for a 100-ton heavy hook capacity operating at a hoisting speed of 10 fpm and the dual capacity will also provide for a 20-ton light hook capacity operating at 40 fpm. On installations where high speed empty hook operation (up to 400 per cent rated speed) is required, time used in approaching the load can be substantially reduced.

4. The hoist system is comprised of standard a-c or d-c components, relays, contactors, current limiting devices, etc., which are familiar electrical components to plant maintenance personnel. In addition, since there is only one set of hoisting equipment and electrical equipment, there is approximately half of the normal maintenance required with this system as compared to double hoist arrangements.

5. The speed control characteristics in either the heavy hook range or the light hook range of the multi-hoist system provide multiple steps of speed control which are independent of load. The speed droop between no load and full load on any speed handling point is limited to 5 per cent in either the hoisting or the lowering direction.

We currently have five units in operation and additional units under construction; four units are in the field in the Southern California Area on steam plants for the Southern California Edison Co., the California Electric Power Co., and the Salt River Power District near Phoenix, Ariz. The pilot model is installed in the machine shop of our plant. All of these units have proven most satisfactory in operation, exceeding the operational requirements in every case. This crane control possesses all of the inherent requirements of the steel mill industry for dependability, increased production, accurate stable low-speed full capacity operation, high-speed light hook operation and utilization of standard components for minimum maintenance and upkeep.

The paper discusses the development, application, characteristics and operating data pertinent to use of this type crane control system in the steel industry.

"ALLEGHENY LUDLUM STEEL CORP.'S NEW FORGE SHOP, DUNKIRK, N. Y."

by EMIL KERN, Vice President in Charge of Engineering, Allegheny Ludlum Steel Corp., Brackenridge, Pa., and J. E. TRABITS, Plant Engineer, Allegheny Ludlum Steel Corp., Dunkirk, N. Y.

EMIL KERN

△ THE authors describe Allegheny Ludlum Steel Corp.'s new Forge Shop at the Dunkirk Works, N. Y.

This shop was laid out for shaping large ingots of tool steels and special metals into blocks, disks, slabs, heavy flats, sleeves and the like, and also to forge blooms and billets of these metals on a production basis.

Information is given on the general layout of the shop, its buildings, cranes, the press, furnaces and all other equipment installed. Technical data are augmented by slides.

The 2000-ton general purpose forging press has many noteworthy features, considered to be an interesting departure from known designs and an improvement over the conventional four-column type press for this class of work. The floor mounted control pulpit for the forging manipulator is arranged to control the press also. The same man, while running the manipulator, will set the press to stroke automatically between preset limits with a selected penetration speed or forging pres-

J. E. TRABITS

sure or both. Number of strokes per minute may be adjusted to the speed of manipulation.

The paper also describes those features of the installation which tend to increase the production rate and flexibility of the press, decrease the manpower requirements, simplify maintenance, promote good housekeeping and safety.

Good thoughts of many people have been fused into this shop.

"A MODERN FORGING PRESS AND ITS CONTROL"

by O. HOFFMANN, Vice-President of Engineering and A. KRYNYTZKY, Mechanical Engineering Supervisor, Lake Erie Machinery Corp., Buffalo, N. Y.

O. HOFFMANN

△ ALTHOUGH today's automation will probably not overshadow its forefather, the industrial revolution, no one can deny that it is deeply affecting our lives. To consumers it means getting better products at a lower cost, while to labor it means better and safer jobs. While the industrial revolution replaces labor by machines, a characteristic feature of the automation is the replacement of manual control by machine control. This new development turns to instruments tasks formerly performed by man's hands and minds. It does not outlaw, displace or dispense with man. On the contrary, it is a means of increasing man's stature and of extending his ability to do more and more useful work to produce in greater volume with less physical effort or mental strain.

A. KRYNYTZKY

Efficient operation of a forging press to meet the varying demands of a modern shop can be accomplished by the following:

1. Utilizing the controlled tonnage of the press required to deform the given material.
2. The ability to forge automatically to pre-selected dimensions by using the efficient position controls.
3. The use of the fully controlled penetration speed at rapid advance and return.
4. The utilization of multi-slide table for quick tool changing.
5. By making the operation of the press, as well as its maintenance—simple, foolproof and safe.

This paper deals with the description of a recently installed 2000-ton general purpose forging press, its design features, drive, control and auxiliary equipment.

The press is of the three-cylinder, two-column, pull-down type and has a lateral tool changing sled. The many advantages of this type, such as lower center of gravity, greater stability, lower head room requirements and so on are described.

The drive, a bank of electrically driven oil hydraulic axial piston pumps, with all its power and pilot piping is installed underground.

The control cycles for the press, the position control, the tool slide design and other features are also described.

"SOME HEAVY INDUSTRIAL NOISE PROBLEMS, THEIR ANALYSES AND SOLUTIONS"

by RICHARD D. LEMMERMAN, Manager, and RICHARD R. AUDETTE, Assistant Chief Engineer, Industrial Sound Control Dept., Koppers Co., Inc., Baltimore, Md.

R. D. LEMMERMAN

△ THE problem in industrial noise, which has arisen seemingly only recently to plague both management and the safety engineering personnel, is in reality not a new one. Rather, instead, the cognizance of noise as a major industrial problem is new. Increased economic pressures through the new proximity of residential areas in the case of the residential noise problem and the results of ear damage compensation claims, together with union demands for improved working environments, have spurred more recent interest in the noise problem.

The aircraft engine industry has been plagued with serious noise problems for two decades and other industries with increased interest in the noise problem are beginning to move along the same path followed by the aircraft.

R. R. AUDETTE

Similarly, the basic engineering approaches to industrial noise problems are relatively new, developed by the demands of the aviation industry. Instrumentation and measurement techniques, together with basic information as to how people react to noise environmentally, have made substantial strides in the last few years, thus allowing noise control to move from the realm of theoretical physics to that of a true engineering science.

This paper examines noise in the framework of its effect upon people and discuss several solutions to industrial noise problems through the analysis of typical case histories of industrial noise problems.

"TEN PAINTING 'REMINDERS' FOR STEEL PLANTS"

by WALTER T. YARHOUSE, Industrial Sales Representative, The Sherwin-Williams Co., Cleveland, Ohio

W. T. YARHOUSE

△ THE discussion of this subject favors the practical approach and considerations which have an every day influence on the decisions made by the men responsible for the maintenance painting in steel plants. It develops from interviews with a representative painting maintenance engineer, a maintenance supervisor, a general foreman of maintenance painting, a consult-

ant and a painting contractor who specialize in steel plant work.

In developing the subject, it is with reference to the published recommendations of the Steel Structures Painting Council and proceeds in the following continuity.

1. *Supervision*—Types, necessity and importance.
2. *Cleaning*—Methods, degree, necessity, importance and value.
3. *Painting conditions*—Atmospheric, temperature and seasonal.
4. *Thinning*—Control.
5. *Application*—Brushing, spraying and roller coating.
6. *Film thickness*—Control and importance.
7. *Specifications*—Formula, proprietary brand, performance and testing.
8. *Standardization and records*—Value and need.
9. *Buying of materials and services.*
10. *Color*—Desirability, necessity and value.

The "conclusion" includes comments regarding new types and formulations of paint products for specific purposes, as well as forecasts of expected future products based on present technical research and developments.

"IMMERSION THERMOCOUPLE PRACTICE"

by H. V. SCHUBERT, Fuel Engineer—Seattle Plant, Bethlehem Pacific Coast Steel Corp., Seattle, Wash

H. V. SCHUBERT

△ THIS paper is concerned with the basic design, construction, application and maintenance of the "bath thermocouple," one of the modern "tools" of the steel industry.

Although it is recognized that proper application and adequate instrumentation are important factors, considerable emphasis is placed upon thermocouple maintenance. A daily record of thermocouple performance coupled with a classification of the type of reading obtained, methods of checking the accuracy of the thermocouple and the condition of its components are discussed.

"CONTINUOUS ANNEALING 60 TONS PER HOUR OF TINPLATE"

by QUENTIN M. BLOOM, Manager, Furnace and Kiln Div., Selas Corp. of America, Dresher, Pa.

Q. M. BLOOM

△ THIS paper discusses the characteristics and operation of four one-pass, direct-gas-fired furnace lines continuously annealing tinplate stock at the Sparrows Point, Maryland, plant of Bethlehem Steel Co.

Performance data and metallurgical information are presented to illustrate the reasoning and objectives of obtaining 60 tons per hour in a multiple-line installation.

Some of the highlighting features described, include:

1. How the unique, retractable furnace design provides improved safety measures.
2. How the compactness and simplicity of the entire installation reduces investment and operating costs.
3. How multiple-line flexibility of production helps coordination with varying market and product requirements.
4. How the one-pass design reduces operational difficulties.
5. How, in a complete annealing cycle of less than one minute, desired physical strip properties are obtained.

"SAFEGUARDING STEEL PRODUCTION"

by R. M. L. RUSSELL, Assistant Chief Engineer, Factory Insurance Association, Hartford, Conn.

R. M. L. RUSSELL

△ STEEL might well be called America's lifeline to survival in a world being torn asunder by political and economic strife.

Any instrumentality cutting this lifeline, interrupting steel production, from within our shores, is as great a threat to existence as a free people as though such disaster came upon us from a foreign shore.

Fire (or explosion) is one of the most widespread and powerfully destructive perils which today, as in the past, overshadows American industry—and steel is no exception.

Reduced to the simplest terms, the steel industry can meet and overcome, to a large degree, the fire peril by taking the following steps:

1. Assuring that a new plant site has an inexhaustible unfailing water supply available, adequate for maximum service and fire protection needs.
2. Selecting construction materials that are noncombustible or fire resistive. If for reasons of economy and durability, coated metals are used for building roofing or siding, those types which have been tested and listed by the Underwriters' Laboratories as having very low flame spread (noncombustible rating) should be used in areas not requiring sprinklers. Where an occupancy requires sprinkler protection, a wider selection of construction materials may be made.
3. Assuring that all important electrical transmission and distribution lines are completely protected, not only from lightning and overloading by suitable protective gear, but also sufficiently clear of all facilities that might bring about a power outage resulting from mechanical injury.
4. Following prescribed safe methods for the storage, distribution and handling of all types of fuel, including the compacting and frequent temperature checking of coal piles, the safeguarding of fuel oil by using properly equipped and diked well-segregated storage tanks, and the safe arranging of all fuel gas piping well protected with easily accessible emergency shutoff valves.
5. Equipping furnaces and other preheating equipment with adequate and well chosen protective devices intended to prevent the accumulation and subsequent ignition of any unburned fuel gas accumulation. Com-

parable protective devices should also be provided where other fuels such as oil or L.P. gas are used.

6. Properly equipped rolling mills and oil cellars with automatic fixed fire extinguishing equipment selected to quickly extinguish a fire involving lubricant and coolant oils without undue damage to process equipment or the coolant medium.

7. Properly protecting high valued all-important bottle-neck rotating machinery such as found in mill motor rooms with automatic fixed fire extinguishing equipment. In this connection, all combustibles that might initiate or sustain a fire in such electrical rooms should be kept out of such areas.

8. In by-products production and storage areas, all safeguards normally called for in the handling of flammable liquids, including the use of fixed and portable fire fighting equipment, explosion proof electrical equipment, mechanical ventilation, grounding and good housekeeping should be incorporated.

9. Finally, a well organized, well trained and adequately staffed properly equipped private fire department should be maintained as well as a thorough frequent and regular self-inspection program with an effective follow-up system for properly correcting deficiencies that come to light.

"THERMIT WELDING STRUCTURAL MILL ROLLS"

by EDWARD B. RUSSELL, Assistant to Superintendent (Mechanical Shops), Kaiser Steel Corp., Fontana, Calif.

E. B. RUSSELL

△ THIS paper is written with the intent of giving a clear picture of the various steps involved in the application of a thermit weld to replace broken wobblers on the roll necks of various structural mill rolls used for rolling the shapes involved in producing structural steel members.

After a brief history of the discovery of the thermit reaction, a chronological discussion of the necessary steps is maintained in proper sequence illustrated with slides of an actual weld being prepared from start to finish.

Interspersed through this description are charts, diagrams, sketches and practical hints of value to those already engaged in or familiar with thermit welding procedures.

While no attempt is made to cover the entire field of thermit welding, still a considerable amount of the data given is applicable in one form or another to all thermit welding problems.

Preparation of joints, alinement and problems of expansion and contraction are touched upon as well as comparison between conventional wax molding methods vs wood or metal pattern uses.

Particular emphasis is given to the many small details, usually not apparent to the bystander, which, if neglected, will mean failure in producing satisfactory thermit welds.

Also touched upon are the hazards associated with this type of welding and a short discussion of particular safety precautions which should be taken.

"ELECTRICAL EQUIPMENT FOR A MODERN SHEET TEMPER MILL"

by D. E. REA, Application Engineer, Electrical Application Department, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

D. E. REA

△ THE sheet temper mill, or skin pass mill, of single stand construction produces steel in coil form which can be marketed as mill run, or later sheared to specific lengths. The latter product is sold as either cold rolled primes or sheets, depending on surface quality. The steel produced on this type of mill is used in many applications; stoves, refrigerators, furniture, being only a few examples.

To impart a superficial surface hardness to prevent stretcher-strains during subsequent drawing operations, flatness, and retaining the surface quality obtained during cold rolling, are the primary purposes for sheet temper rolling. To meet these requirements, the steel must be cold worked beyond its yield point by a combination of tension and roll pressure. The expanding requirements of a growing population has increased the demand for sheet steel. More production, hence higher speed mills, are needed to meet this demand.

It is the purpose of this paper to present and discuss the application of electrical equipment for a typical sheet temper mill. Test data taken from several mills of this type construction are compiled to use as a basis to support the application procedure.

Higher speeds and shorter acceleration time demand better control and more versatility of the electrical equipment. Little in the past has been presented on the sheet temper mill electrical requirements. The primary purpose of this paper is to present such a discussion.

"ROLLING OF METALS"

by J. I. GREENBERGER, Group Engineer, United Engineering and Foundry Co., Pittsburgh, Pa.

J. I. GREENBERGER

△ THE historical development of the 2-high, 3-high, 4-high and cluster mills is reviewed with particular emphasis paid to mill rigidity.

Various factors involved in the basic rolling process are explained in detail. Work roll size selection for both hot and cold rolling applications and the related effects of roll flattening, the geometrical $\frac{\mu L}{T}$ factor and roll pressure limitations are covered. Rolling characteristics of the material being rolled also affect proper mill selection and recommended rolling practice. The effect of rolling speed on the coefficient of friction is discussed and a relationship suggested for the material temperature as affected by speed of rolling.

Use of power curves by the mill engineer is reviewed and a suggested modification to increase their usefulness

is offered. Some apparent contradictions when rolling aluminum and magnesium are discussed.

Typical rolling practice for producing tin plate or sheet product from the original ingot form is followed in detail. Types of slabbing mills, hot mills, cold mills and temper mills and their typical productivities are analyzed. In certain rolling operations, practice is established by metallurgical limitations and demands.

Parallel developments and advances in instrumentation, electrical controls, bearings, lubricants, etc., have contributed materially to recent rapid studies in rolling of metals.

"MECHANICAL MAINTENANCE AT THE PUEBLO PLANT OF THE COLORADO FUEL AND IRON CORP."

by JEROME L. LINDBERG, Assistant to Director of Mechanical Maintenance, The Colorado Fuel and Iron Corp., Pueblo, Colo.

J. L. LINDBERG

△ A MODERN maintenance organization can no longer look with indifference or unconcern on the problems confronting others after being told *"It ain't mechanical."* Rather, the responsibilities of such an organization now extend beyond preventing breakdowns and include such basic functions as cost reduction, improving productive output and increasing quality of product. These responsibilities are recognized objectives of the mechanical department at the Pueblo plant of the Colorado Fuel and Iron Corp. This department, charged with the over-all responsibility of all mechanical maintenance in the mill, performs in addition several other key functions such as manufacturing spare parts, performing major construction of new facilities and providing shop service to other plants in the corporation. The department, although organized as an integrated group, is sub-divided into three general categories; namely, the mechanical shop units, the assigned maintenance units, and the construction, bricklaying, locomotive crane and labor units.

Due to the remote location of the plant, it is necessary that the shop units, in addition to repairing worn equipment, must be able to fabricate and erect complete new installations, provide practically any spare part used in the mill and assume full responsibility for training all necessary personnel. The shops constitute approximately 45 per cent of the employees in the department and include such major units as the machine, boiler and weld shops, a casting foundry, and in addition, carpenter, pattern, pipe, blacksmith and scale shops.

All bricklaying, with the exception of open hearth relines, together with all necessary excavation and concrete emplacement, is carried on by the department. Additional duties include yard and road maintenance, stock piling and craft painting.

The functions of the maintenance units, many of which are responsible for mills more than 60 years old, have become more critical with the advent of automation and inter-related equipment. This maintenance is performed by millwright crews, supplemented by craft personnel assigned from the shops units. In addition to maintaining the mills, these units are intimately concerned with the development of improved processes and equipment resulting in increased productivity. In addition, continually expanding programs of preventive maintenance, developed in conjunction with operating crews, are among the primary functions of these units.

Revised and rearranged collection of articles which appeared in the Iron and Steel Engineer between 1943 and 1950 . . . a book for rolling mill men and for anyone interested in rolling mills and roll design . . . written from a practical viewpoint by one who has had considerable experience in the art of roll design.

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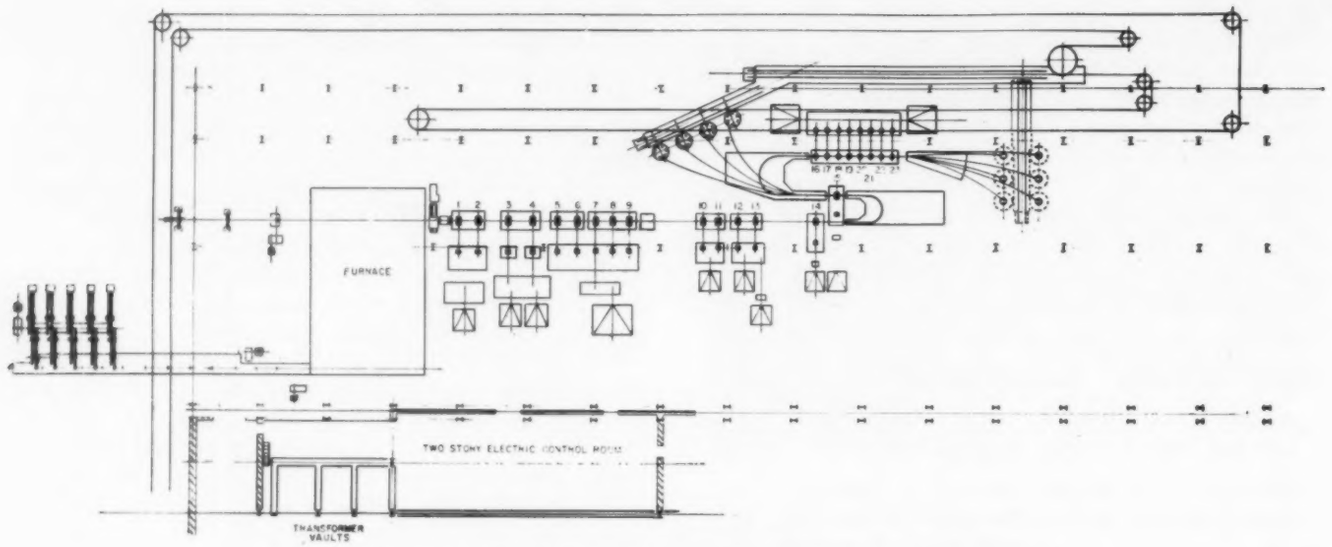


Figure 1 — General plan of new rod mill at Bethlehem's Johnstown plant.

. . . . to get the best performance out of a modern rod mill, careful and thorough consideration must be given to the many details required in laying out and selecting the right electrical control equipment and drives . . . .

Electrical Equipment

by E. L. ANDERSON
Superintendent
Electrical Dept.
Bethlehem Steel Co.
Johnstown, Pa.

THE rod mill at the Johnstown plant is a modern 23-stand, 3-strand, high-speed mill, consisting of nine roughing stands, six intermediate stands and eight finishing stands. It is driven by 11 motors totalling 7450 horsepower, and is designed for rolling in coils, rods of sizes $\frac{7}{32}$ in. to $\frac{3}{4}$ in. diam. The mill is arranged for operation on either of two lines. The "B" line, a two-strand operation, rolls rods $\frac{7}{16}$-in. and larger through the first repeater, finishing out of No. 15 stand into four pouring reels. The "A" line, a three-strand operation, rolls rods $\frac{7}{16}$-in. and smaller, finishing out of either of stands Nos. 17, 19, 21, or 23 into six laying reels.

Figure 1 shows the general arrangement of the mill.

Power is purchased from the Pennsylvania Electric Co. at 23,000 volts, 3-phase, 60-cycle. Two circuits are provided, one feeding from their Broad St. Station and one from their Seward Station. Either circuit has sufficient capacity to carry the mill at full load operation.

Figure 2 shows a one-line diagram of the outdoor substation. This station consists of one 34.5-kv, 3-pole, 1200-amp, oil circuit breaker serving the three rectifiers and a similar breaker serving two 1500-kva, 23kv/460-volt, 3-phase transformers for auxiliary power. A 150-kva, 23-kv/240-volt, 3-phase transformer, for potential and control purposes, is connected to the 23-kv bus through fused disconnecting switches.

Power is supplied directly to the primary of the rectifier transformers at 23,000 volts, 3 phase, 60 cycle. A set of gang-operated disconnecting switches, interlocked with the oil circuit breaker, are provided so that any one of the rectifier transformers may be isolated. The oil circuit breakers are air-operated, each with a self-contained air compressor, power for which is furnished from the control power transformer.

A 48-volt battery located in the motor room provides power for operating the closing and trip valves for the operation of the oil circuit breakers.

Connections between the outdoor substation the three rectifier transformers and the two 1500-kva, 440-

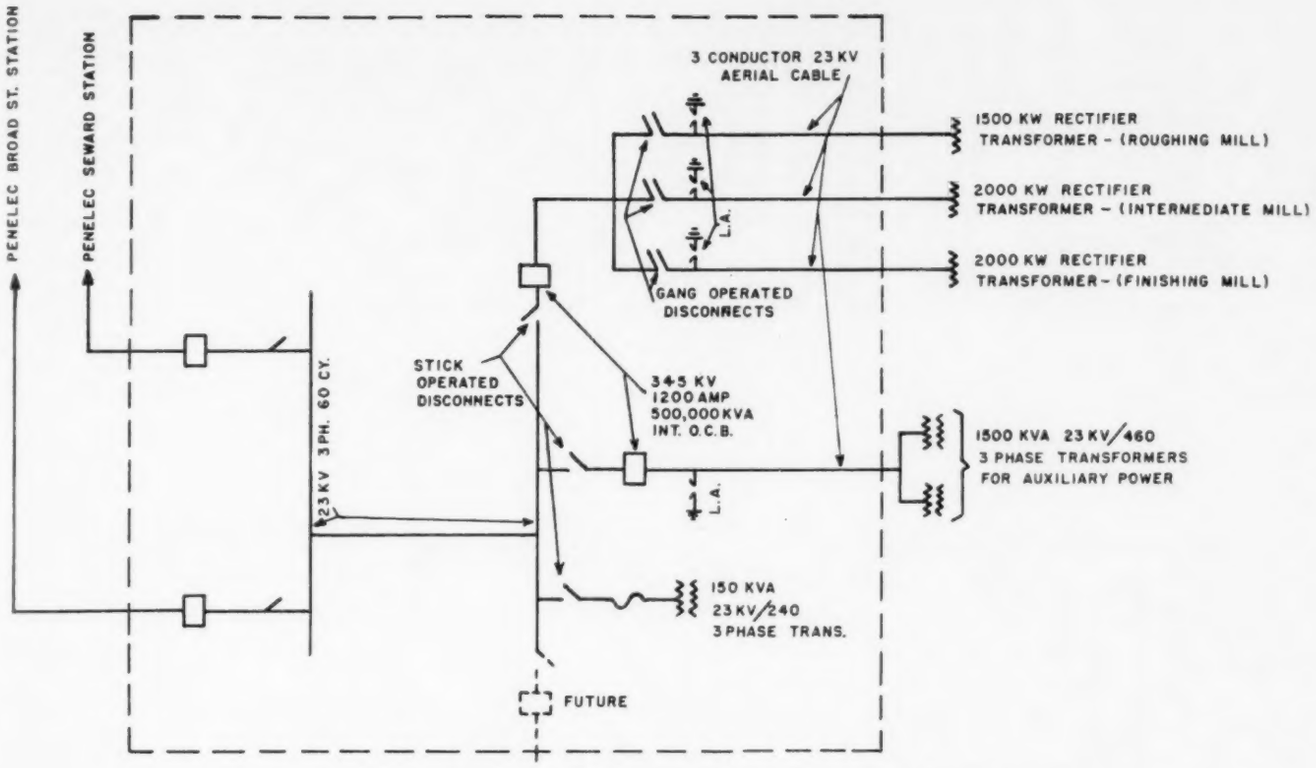

PENELEC BROAD ST. STATION
PENELEC SEWARD STATION
3 CONDUCTOR 23 KV AERIAL CABLE
1500 KW RECTIFIER TRANSFORMER - (ROUGHING MILL)
2000 KW RECTIFIER TRANSFORMER - (INTERMEDIATE MILL)
2000 KW RECTIFIER TRANSFORMER - (FINISHING MILL)
L.A.
GANG OPERATED DISCONNECTS
STICK OPERATED DISCONNECTS
345 KV 1200 AMP 500,000 KVA INT. O.C.B.
23 KV 3PH. 60 CY.
1500 KVA 23 KV/460 3 PHASE TRANSFORMERS FOR AUXILIARY POWER
150 KVA 23 KV/240 3 PHASE TRANS.
FUTURE

Figure 2 — One line diagram of 23-kv outdoor substation for 3-strand rod mill.

for a Modern Rod Mill

volt, auxiliary power transformers are made by 23-kv, 3-conductor aerial cables. These cables are made up of three No. 1 AWG, 19 strands of copper, $^{32}/_{64}$-in. varnished cambric insulation with Type M shield over each conductor. A No. 8 AWG bare ground wire is woven in each interstice to localize the fault and minimize burning of the cable in case of failure. A 0.090-in. tape-type synthetic jacket, 0.025-in. galvanized steel interlocking armor and a 0.025-in. polyvinyl chloride jacket over-all for 23-kv ungrounded neutral service. Although the neutral of the 23-kv system is solidly grounded, it was felt advisable to install cable suitable for ungrounded service as an additional safety factor since the increased cost was a small percentage of the total investment.

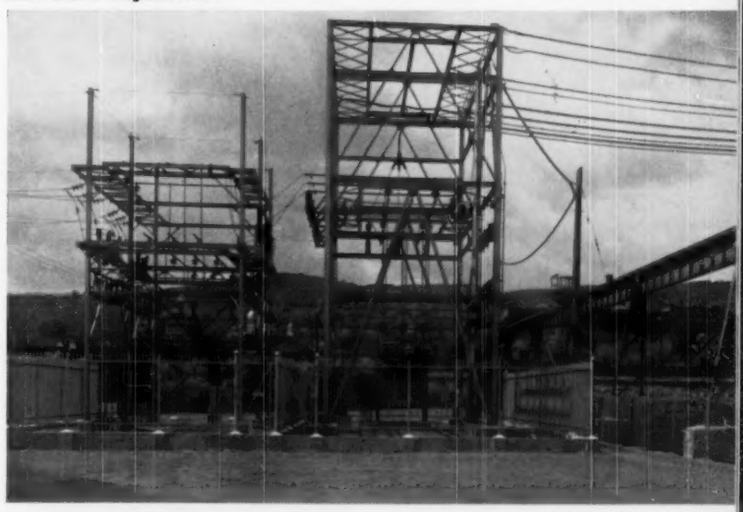
The oil circuit breakers have an interrupting capacity of 500,000 kva, and were installed at this rating to provide for possible growth and enlargement of the power company's system. Space is provided in the outdoor substation for one future circuit, and the station can be extended, for additional circuits, if it is required in the future.

Power at 250-volt direct current, for various mill auxiliaries, cranes, etc., is provided by rotary converters operating on the 25-cycle system.

Figure 3 shows the outdoor substation. Note that the power company's station and the steel company's station are adjacent to each other and enclosed by the same fence.

All equipment for operation of the mill, including rectifiers, main control, auxiliary control, exciters, etc., are located in a central motor room.

Figure 3 — Power company's and steel company's substations are adjacent.



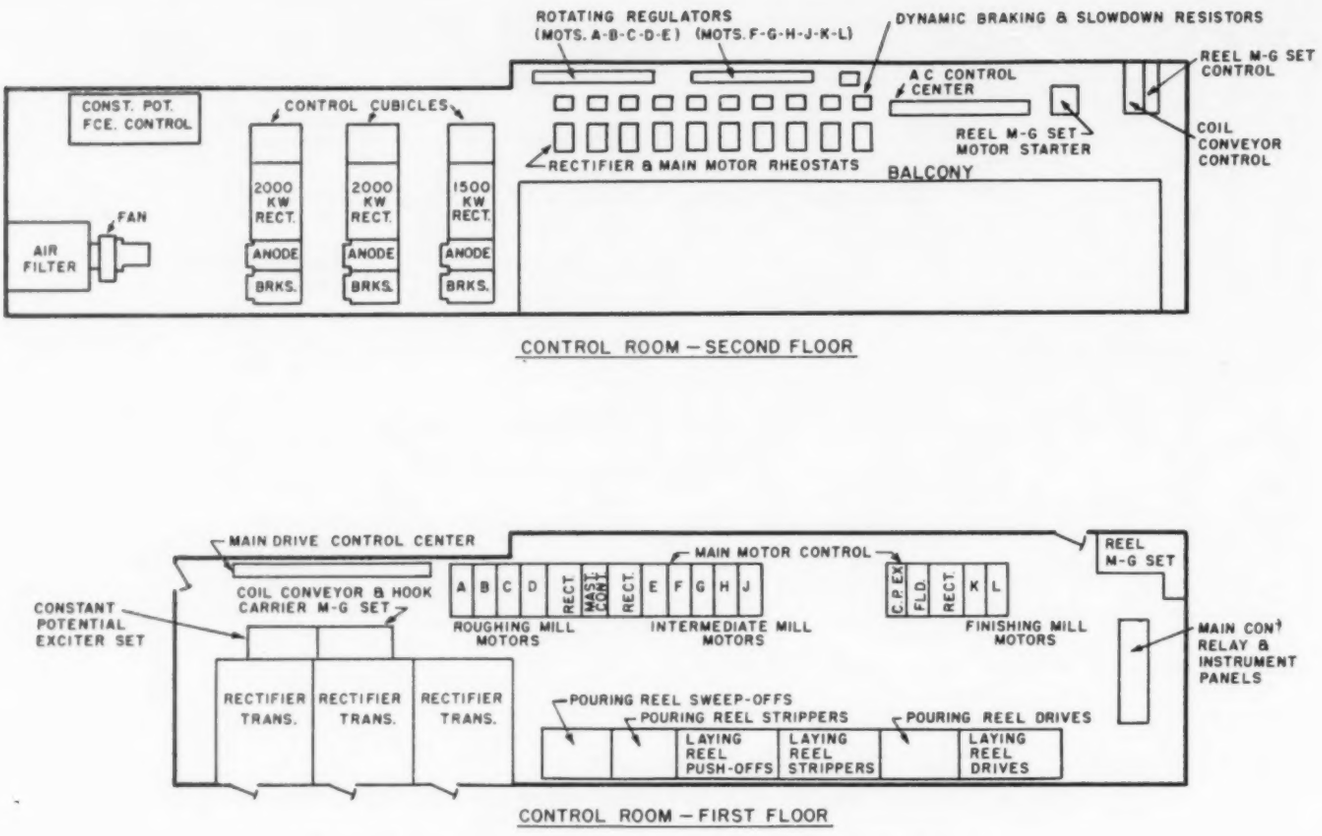


Figure 4 — Floor plan of general layout of electrical equipment.

Figure 4 shows the floor plan of the first floor and the floor plan of the second floor and balcony in the motor room. The rectifier transformers are located inside the mill building and as a part of the motor room. Due to the location, water-to-oil heat exchangers were provided for cooling the transformers. The transformers are located on the ground level and directly above them, on the balcony, are the anode breakers and the rectifiers. This makes a compact arrangement, requiring a minimum of space and providing for short leads between the component parts.

The rectifiers are of the pumpless type and designed to receive 23-kv, 3-phase, 60-cycle power at the transformer primary and convert it to 700-volt direct current. The rectifiers are rated 100 per cent load continuous, 125 per cent rated load for two hours following 100 per cent load, 200 per cent load for one minute following 100 per cent load. Each rectifier is provided with a voltage regulator to maintain the selected d-c voltage constant within one quarter of one per cent from light load to rated current. The rectifier transformer is compensated so that rated d-c voltage can be maintained up to 125 per cent current when the a-c voltage is 95 per cent of its rated value. The d-c voltage range of 595 to 700 volts is provided by phase control.

The transformers are provided with three 2½-per cent taps below rated primary voltage and one 2½-per cent tap above rated primary voltage. These taps are for compensating differences in line voltage. In addition to the above mentioned taps three 5-per cent taps are provided below rated voltage. These taps are provided so that the rectifiers may be operated at an optimum power factor should it become necessary to operate the mill continuously at a d-c voltage lower than the normal range of 595 to 700 volts. The two sets of taps are completely independent of each other.

A 1500-kva rectifier, with the transformer primary connected delta, serves the roughing mill. One of the 2000-kva rectifiers, with the primary connected delta, serves the intermediate mill and the second 2000-kva rectifier, with the primary connected wye, serves the finishing mill. The primaries of the two 2000-kva rectifier transformers are connected delta and wye in order to reduce harmonic current which would cause interference on telephone and communication systems.

In normal operation, the finishing mill rectifier is operated at full voltage or 700-volt direct-current. The roughing mill and intermediate mill rectifiers are phased back to approximately 660 volts. This is done to provide for speed adjustment of either the roughing or intermediate mills so that a loop can be maintained between No. 9 and No. 10 stands or between the two mills.

Power factor on the purchased power system averages 0.82 lag with a normal rolling of three strands of 2½ x 2½-in. billets, weighing 630 lb each, to ¼-in. diam. rod at a speed of approximately 5000 fpm.

Figure 5 shows curves indicating the load on each of the rectifiers and the power factor on the feeder serving them.

Power consumption on the mill, for average rolling and finishing out of No. 23 stand, is as follows:

Main drive motors—82.6 kwhr per ton.

Main drive auxiliaries, ventilating fans, exciters, etc. 17.3 kwhr per ton.

Miscellaneous auxiliaries, reels, conveyor, etc.—10.3 kwhr per ton.

Demand (15-min.), on the main drive motors is be-

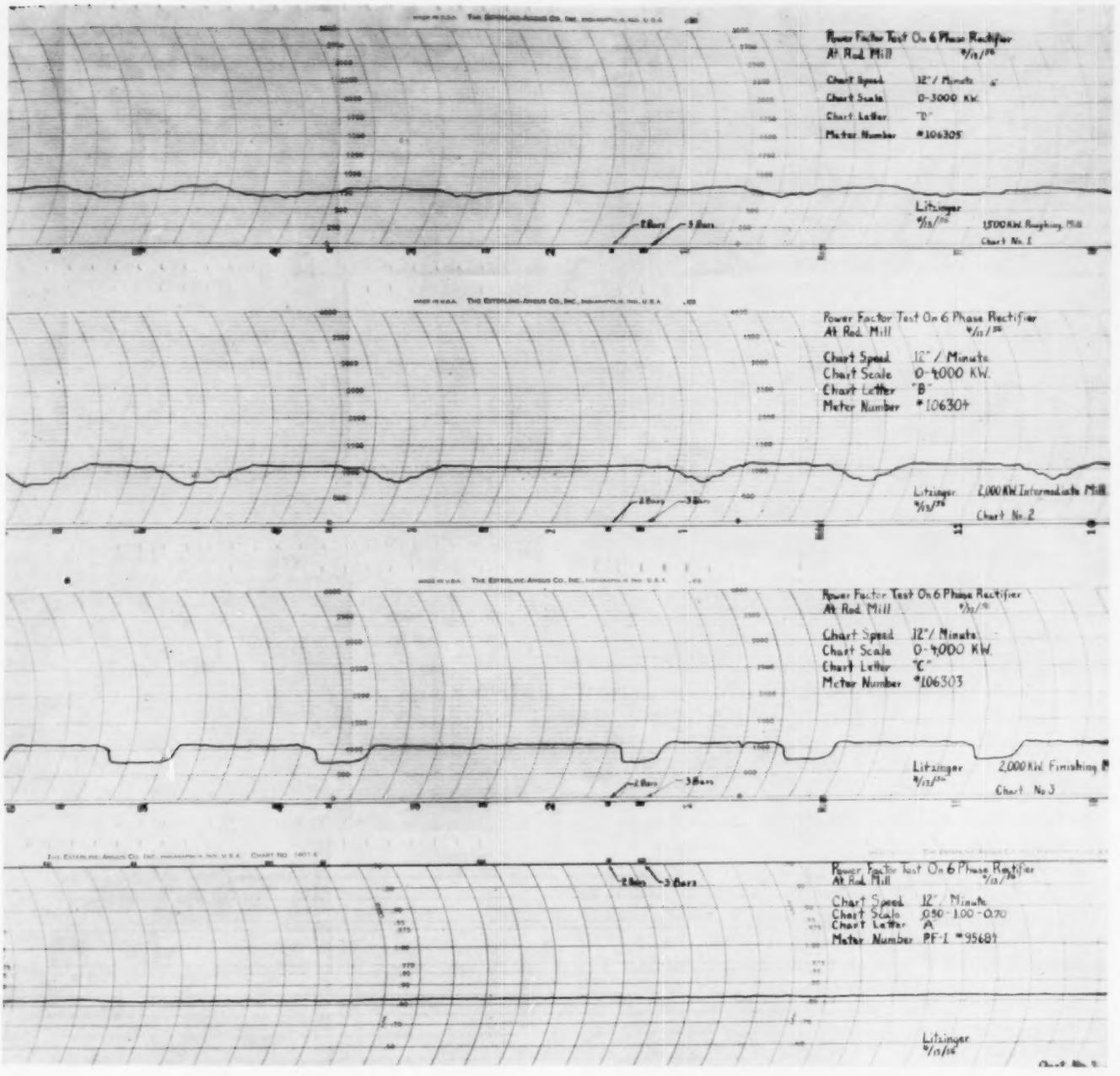


Figure 5 — Charts give load on rectifiers and power factor on the feeder serving them.

tween 4800 and 5400 kw plus 1000 kw for auxiliary drives, making a total demand of from 5800 to 6400 kw.

Under emergency conditions any one of the rectifiers can be taken out of service, and normal operations of the mill maintained, by connecting the three sections of the bus together to form a single bus and paralleling the two remaining rectifiers. The bus sections and control circuits are so arranged that the emergency connections can be made in two hours approximately.

Figure 6 shows a one-line diagram of connections for the main drive equipment.

Figure 7 shows the installation of the rectifier transformers, each one in a separate vault.

Figure 8 shows the motor field rheostats, dynamic braking and slow-down resistors located on the balcony above the main motor control boards.

Figure 9 shows the main motor control panels.

Figure 10 shows main instrument and control panel, from which main motor operating set-up is made, and ventilating fans, exciters, rotating regulators, motor heaters and, etc., are operated.

A 25,000-cfm blower, discharging at 2½-in. water pressure through a rotating oil bath screen filter, is provided for ventilation of the motor room. The blower is driven by a 15-hp, 900-rpm motor and is located at one end of the motor room on the second floor. Air passes through the entire length of the motor room and is discharged through self-closing louvres at the opposite end of the motor room.

Due to the fact that operation of the 10-in. rod mill had to be maintained while the equipment for the new mill was being installed, the problem of getting wiring between the panels located in the motor room and the new motor foundations presented quite a problem. This was solved by providing a wiring tunnel running the entire length of the motor room.

Figure 11 shows a portion of this tunnel with the wiring in place.

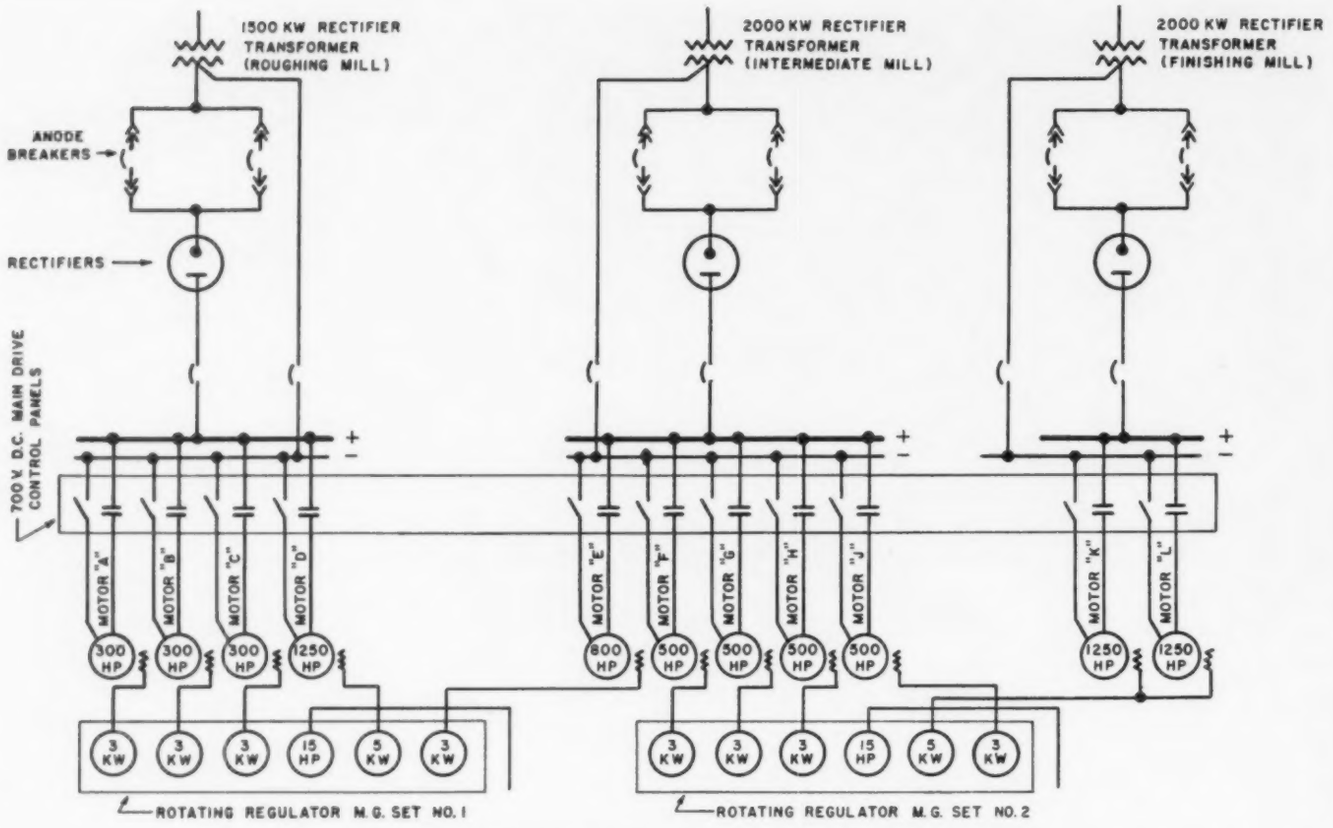


Figure 6 — One-line diagram of connections for main drive equipment.

The entire motor room equipment was installed and wired with the old mill in operation. The 4000-hp motor driving the old mill was located in the open area between the intermediate and roughing-mill main motor control panels.

All leads from the main control panels to the main-drive motors consist of cables pulled in conduits. The conduit system for main drives, auxiliary drives and all controls is carried through a system of manholes, located at strategic positions throughout the mill. All cables on the 700-volt d-c system are rubber insulated for 1500-volt service. The balance of the wiring on 440-volt and under is rubber insulated for 600-volt service.

In laying out the mill it was found that a number of the motors would be located over existing foundations. In order to save time and reduce construction costs, it was felt desirable to eliminate the pits under the motors. With the pits eliminated, the method of ventilation became a problem. To overcome this difficulty, it was

Figure 7 — Each rectifier transformer is in a separate vault.

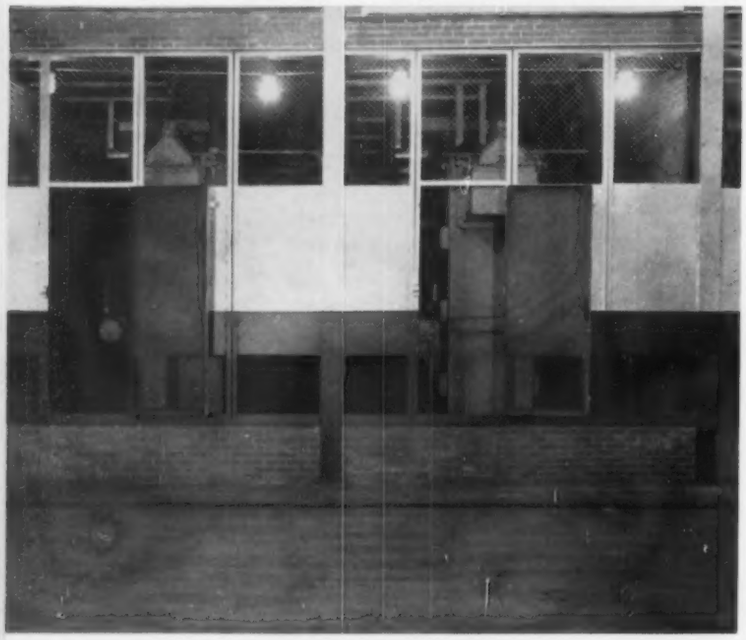


Figure 8 — Motor field rheostats, dynamic braking, and slow-down resistors are located in balcony.

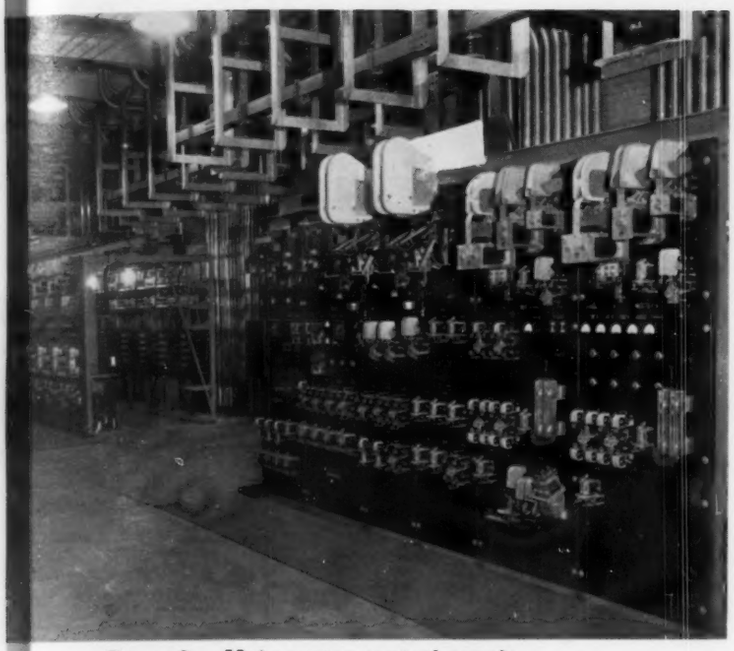


Figure 9 — Main motor control panels.

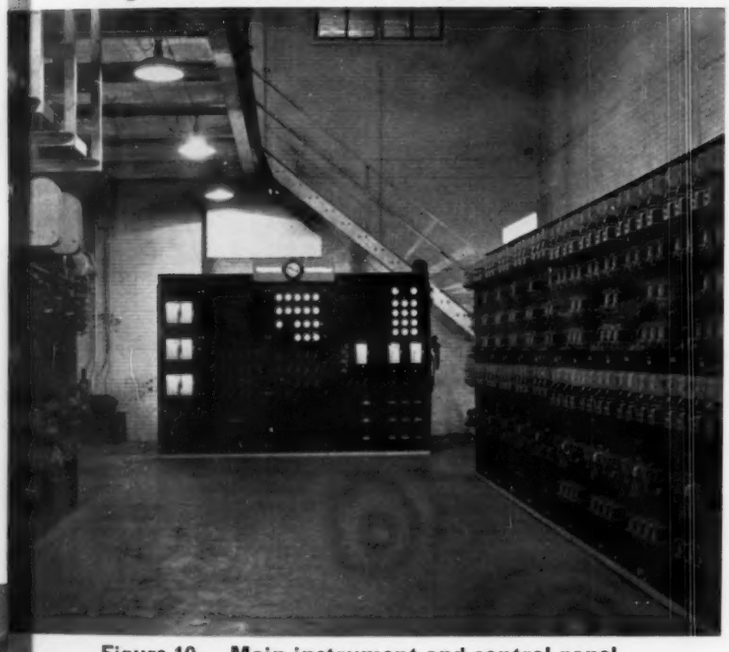


Figure 10 — Main instrument and control panel.

Figure 11 — A wiring tunnel runs the entire length of the motor room.

decided to build each motor with a self-contained cooling and ventilating system and with the leads brought out on the side of the frame so that all connections could be made above the mill floor.

Figure 12 shows an outline of a typical motor used on this mill. Indicated is the location of the water-to-air heat exchanger and the axial-flow fans used for circulating the air within the motor. The installation has proved entirely satisfactory and has saved considerable expense in construction costs.

Table I shows the ratings of the various main drive motors I with their attendant rotating regulators.

On many rod mill installations in the past, it was felt desirable to supply motors with high-inertia armatures, the theory being that with a flywheel essentially built into each armature, the impact speed drop caused by the rod entering the rolls in the various mill stands would be reduced to a minimum since the inertia of the armature would tend to prevent any drop in speed. In this mill, however, the use of high-inertia armatures was eliminated, and motors having standard armatures were used. Impact-speed drop is compensated for by a high-speed regulating system. A tachometer generator, coupled to the individual mill motors supplies the input signals to a magnetic amplifier. This amplifier controls the output of a rotating type regulator connected in the motor field circuit and regulates the mill motor

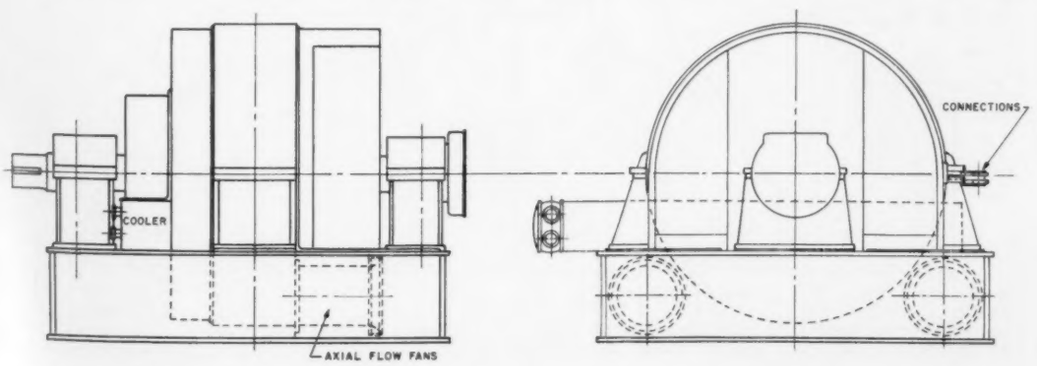


Figure 12 — Outline of main motors used on 3-strand rod mill.

TABLE I
Tabulation Main Drive Motors

Mill	Strands	Motor	Hp	Rpm	Volts	Rotating regulators	Constant potential exciter
Roughing	1–2	A	300	250– 625	700	3 KW	One 75-kw, 250-v, d-c generator driven by a 125-hp, 440-v, 3-phase 60-cycle 1800-rpm motor
	3	B	300	250– 625	700	3 KW	
	4	C	300	250– 625	700	3 KW Driven by a 15-hp, 440-v, 3-phase, 60-cycle 1800-rpm motor	
	5–9	D	1250	225– 562	700	5 KW	
Intermediate	10–11	E	800	300– 750	700	3 KW	
	12	F	500	500–1220	700	3 KW	
	13	G	500	500–1220	700	3 KW	
	14	H	500	200– 600	700	3 KW Driven by a 15-hp, 440-v, 3-phase 60-cycle, 1800-rpm motor	
	15	J	500	250– 750	700	3 KW	
Finishing	16–23	K	1250	575– 980	700	5 KW	
		L	1250	575– 980	700		

speed to a preset value. This high-speed regulating system has given very satisfactory operation. Motors can be controlled with a small variation of speed over the entire range.

Figure 13 shows schematic diagram of the control system.

Figure 14 shows a comparison of characteristic curves of speed drops on motors with high-inertia armatures and motors with low-inertia armatures and a high-speed regulating system.

Table II shows data of exciters, motor-generator sets and rotating regulators used in connection with the main-drive and auxiliary controls.

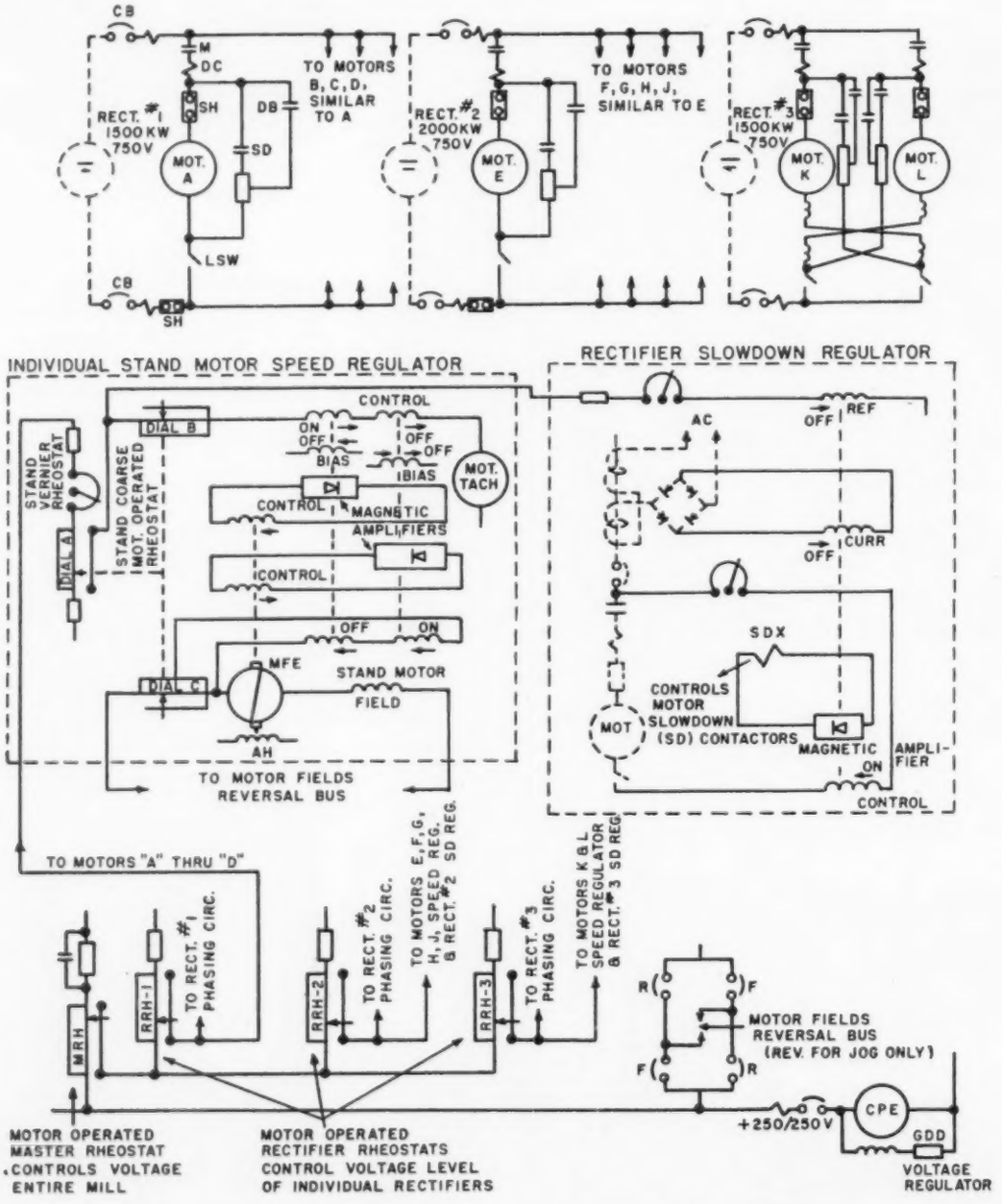


Figure 13 — Schematic diagram shows control system.

Two 15-ton, 100-ft span electric overhead traveling cranes, equipped with double-hook trolleys running parallel to the bridge girders handle the 2½ x 2½-in. or 3¼ x 3¼-in. billets 30 ft-O in. long from the railroad cars to the billet yard and from the billet yard to the billet unscrambling bed. The unscrambling bed mechanically shuffles the billets down four steps to the charging conveyor. The billets are then run, three at a time, by rollers against a disappearing stop and pushed into the furnace by the ram charger. After the ram charger returns out of the furnace, a cross pusher pushes the billets across the furnace hearth. The disappearing stop, ram charger and cross pusher are electrically interlocked to prevent improper operation which would cause damage to the furnace or equipment.

Billets are delivered from the furnace to the mill by the furnace push-out rolls on the charging side of the furnace, and a set of pull-out rolls on the delivery side of the furnace, between the furnace and the switch plate.

Pneumatically operated flying shear and looping pipes are located between No. 9 and 10 stands. Operation of the solenoid valve controlling the air to the shear cylinders is controlled by three flag switches, one for each line, located on the discharge side of No. 7 stand.

Two separate oil-lubrication systems supply the mill. System "A" lubricates the roughing and intermediate mill, pouring reels and drag conveyors. System "B" lubricates the finishing mill and the laying reels. These lubrication systems are completely equipped with audible and visible alarms, and are arranged with duplicate pumps, pressure controlled, so that in the event one pump fails the other will come in automatically. Operation of the pumps can be selected so that the service on them can be equalized.

Figure 14 — Chart compares speed drop on high and low inertia motors and standard motor with regulation.

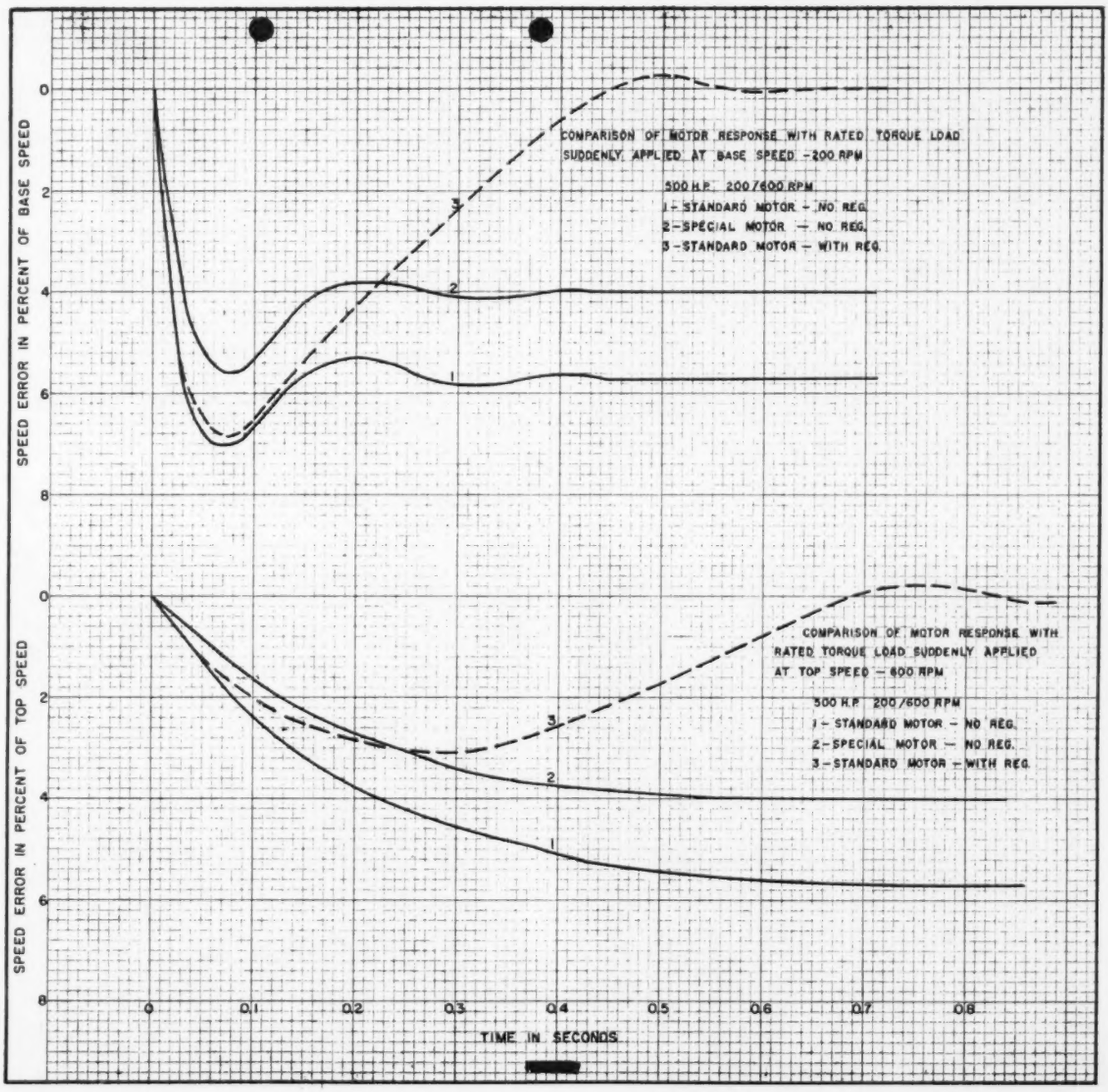


TABLE II
Exciters, Motor-Generator Sets, and Rotating Regulators

Drive	Motors						Generators			
	No.	Hp	Rpm	Volts	Winding	Frame	No.	Kw	Volts	Excited
Constant potential exciter	1	125	1800	440 a-c	Ind.	505S	1	75	250/250	Self
Reels	1	250	1800	440 a-c	Ind.		1	150	475	Exc.
							1	10	250	Self
Conveyor	1	100	1800	440 a-c	Ind.	504S	1	60	475	Rotating exc.
Rotating regulator motors A, B, C, D & E	1	15	1800	440 a-c	Ind.	2847	4	3		
							1	5		
Rotating regulator motors F, G, H, J, K & L	1	15	1800	440 a-c	Ind.	2847	4	3		
							1	5		
Rotating regulator reels	1	2.5	1800				1	1.5		
Rotating regulator conveyor	1	2.5	1800				1	1.5		

Two hydraulic systems provide hydraulic pressure for operation of the various devices throughout the mill. System "A" supplies the billet separating skids and latches, billet discard, side guards on furnace charging table and disappearing stop. System "B" supplies the switch plates, traverse and lift, flying-shear traverse, roll-housing traverse and 23 sets of top roll counter balance cylinders. These systems are supplied with audible and visible alarms to indicate loss of pressure or hydraulic fluid. They are both equipped with duplicate pump systems, so that if one fails, the other one will come in automatically. Operation of the pumps can be selected so that the service on them can be equalized.

The main-drive equipment is controlled from a main pulpit located adjacent to the intermediate mill. This pulpit contains all necessary controls for starting the mill, regulating the speed of the main-drive motors, either by phasing back the rectifiers or by motor field control. Coarse and vernier rheostats are provided in the field of each motor. A supplemental control station is located on the mill floor adjacent to the roughing mill, with speed controls for the roughing mill motors A, B, C and D consisting of the vernier rheostats along with current and speed indication and an emergency stop button for the roughing mill.

In setting up the mill, speeds are preset in the main pulpit. The verniers on the roughing mill control station are set in the center position. With this arrangement, the roller can vary the speed of the roughing mill motors to increase or decrease four per cent.

Provision is made for reversing any one motor or the entire mill. Speed in the reverse direction is limited to the "jogging" speed. The setup for "reverse" is made in the motor room by the mill electricians. After the setup is made, the operator in the main pulpit can run the motor or motors as required.

A public address system is provided for communication between the main pulpit and all parts of the mill. In addition to this "pass lights" controlled from the main pulpit and the finishing mill are set up to show lines that are open and ready to receive billets for the rolling operation. The main pulpit is fully air-conditioned.

Figure 15 presents a view inside the main pulpit, showing the bench board and control devices.

Figure 15 — Controls are conveniently located in main pulpit.

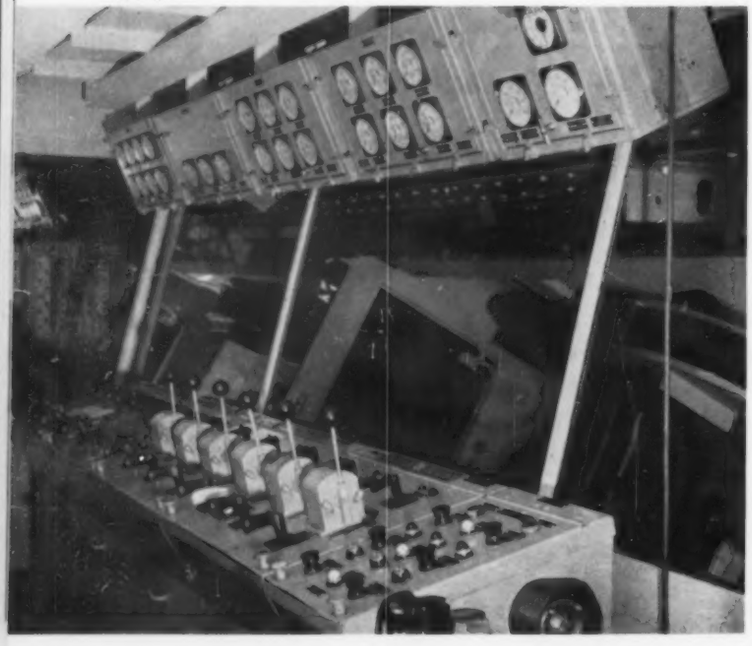
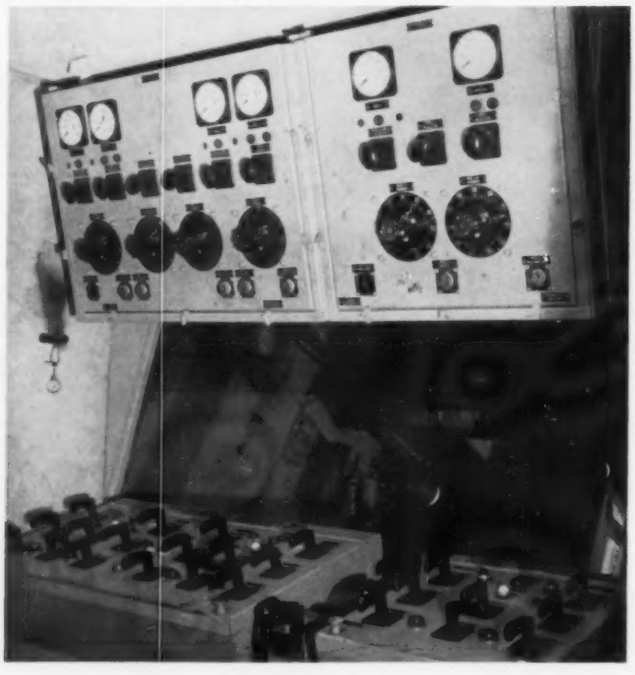


Figure 16 — Reel motor-generator set, circulating water pumps and operations pertaining to the laying reels are controlled from this pulpit.



Since the main drive motors are fed from rectifiers, which will pass current in one direction only, means must be provided to absorb any regenerative power which may be produced during the slowing down of the motors. This is accomplished by slow-down resistors connected by a contactor to each of the three bus sections. The contactors are controlled by voltage relays. When a motor is slowed down, the voltage across the bus rises and when it reaches a predetermined value, the relay closes the contactor and connects the slow down resistor across the bus. As soon as the voltage drops to normal, the relay opens the contactor and the resistor is taken out of the circuit. The time that the resistor is across the bus is of a momentary nature. In addition to the slowdown resistors, it is necessary to provide dynamic breaking resistors on each motor so that they may be brought to rest rapidly. The operation of this phase of the equipment has been entirely satisfactory.

Rod leaving No. 23 stand at approximately 5000-fpm is coiled in 600-lb bundles on six laying reels. These reels are air cooled, and are provided with a hood to cover the rod while it is being coiled, and a push-off to transfer the coil from the reel after the coiling operation is complete on to a conveyor. The operation of the reel is entirely automatic; however, provisions are made for manual operation if and when necessary. The reels are controlled from an air-conditioned pulpit.

Figure 16 is a view of the inside of the pulpit showing the bench board and other control devices. The reel motor-generator set, circulating water pumps and all operations pertaining to the laying reels are controlled from this pulpit.

Figure 17 shows the reels seen from the pulpit.

In automatic operation, a photo-electric eye located ahead of No. 16 stand initiates the operation of the coiling and stripping operations. This includes control of the water sprays, rod switches and air to the reels. The speed of the reels is automatically synchronized to the finishing-mill motors so that any change in the finishing-mill speed, up or down, automatically controls the speed of the reels in the same percentage; thus the speed of coiling is consistent throughout the entire range. Synchronization is provided by the output of a pilot generator driven from the finishing mill motor shaft. The output voltage of this pilot generator controls the voltage applied to the reel motor armatures through a rotating regulator.

The pouring reels consist of four units operating in pairs similar to the laying reels. When the pouring reels are in use, the mill is operated as a two-strand mill. The operation of the pouring reels is practically the same as that of the laying reels with the exception that the photo-cell is located ahead of No. 15 stand, as this is the finishing stand when the mill is serving the pouring reels.

The conveyor system consists of three parts: (1) a section of flight conveyor from the laying reels to the hook carrier; (2) a section of flight conveyor from the pouring reels to the hook carrier; and (3) a monorail type hook conveyor, 1638 ft long, containing 274 hooks transferring the rod from the flight conveyors to the storage dock. One flight conveyor is in operation at a time depending upon which reels are in use. A manually-operated clutch, of the jaw type, is provided to

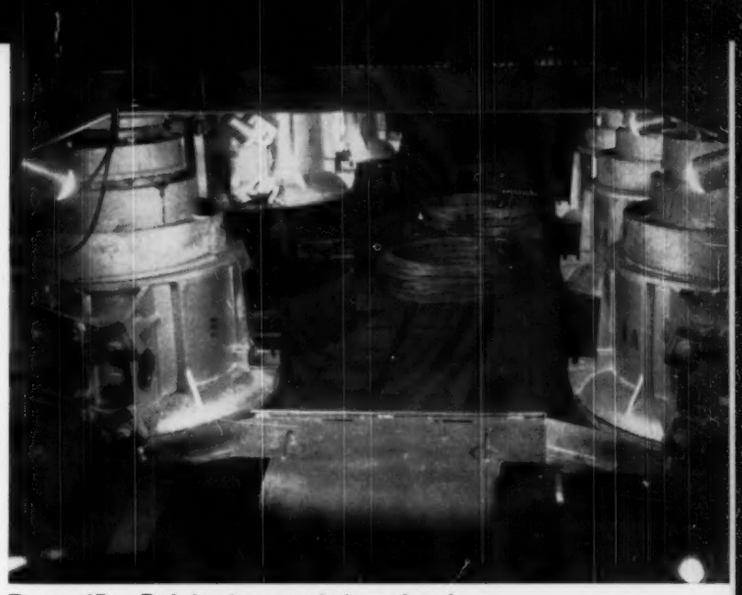
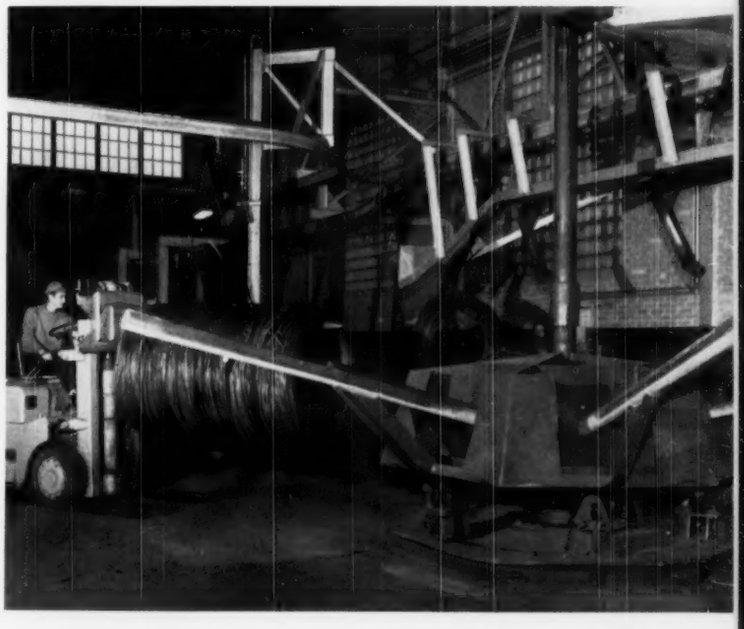


Figure 17 — Pulpit gives good view of reels.

Figure 18 — A section of flight conveyor moves coils from laying reels to the hook carrier.

Figure 19 — Coils are automatically dropped off hook carrier onto a "lazy susan."



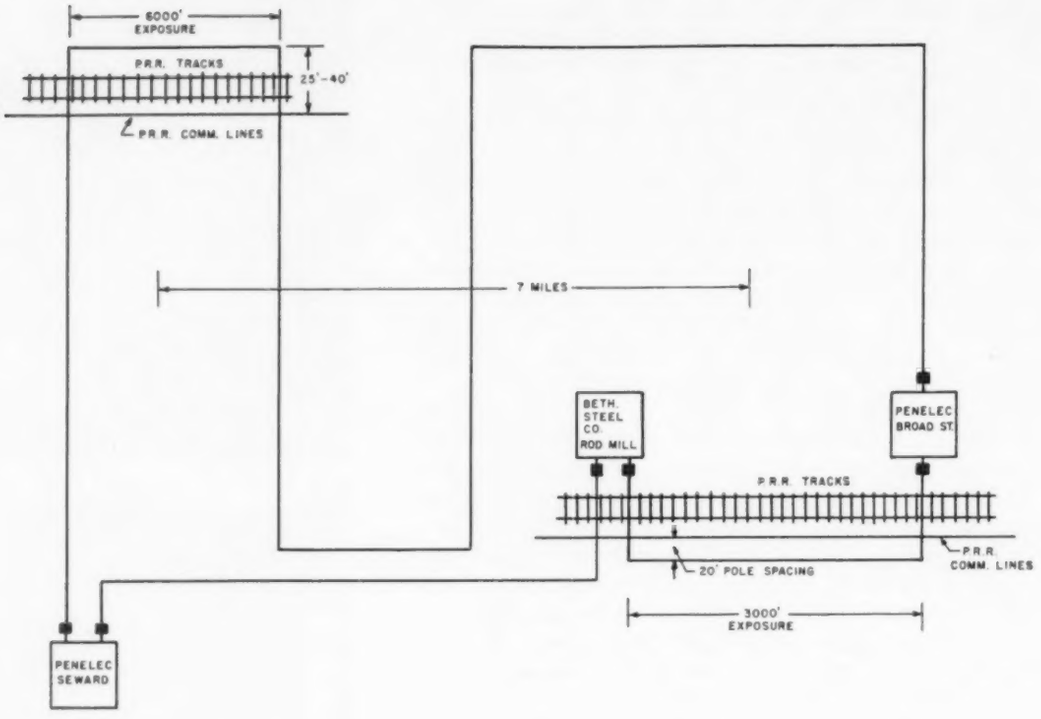


Figure 20 — Original 23-kv power system which fed rod mill.

select between the flight conveyor serving the laying reels and the flight conveyor serving the pouring reels. A star wheel at the end of the flight conveyor transfers the coils from the flight conveyor to the hook carrier.

Figure 18 shows the star wheel at the end of the flight conveyor, where the coils are picked up by the hook carrier.

Coils from the hook carrier are automatically dropped off onto a capstan or "lazy susan," driven by a 1-hp, 1500-rpm, 220-volt, 3-phase, 25-cycle induction motor. Control of this is a simple reversing, push button starter controlled by the operator stationed at this point.

Figure 19 shows the "lazy susan."

The operation of the rectifiers has been entirely satisfactory. A few arc backs have been experienced but these have not been serious and have not affected operations. On the whole we are in favor of rectifiers. To date the maintenance on them has been considerably less than that of a corresponding motor-generator set. They are much easier to put into operation, and there are no commutators or brushes to maintain.

One problem the rectifiers have caused is interference to the communication system of the Pennsylvania Railroad.

Figure 20 shows schematic location of the out-door sub-station, the power company's transmission circuits and the PRR communication lines. The power company's transmission is standard, outdoor aerial construction, consisting of three conductors on wood poles. PRR communication system consists of a large number of open wires, also on wood pole construction. About 3000 feet of the power company's transmission system parallels the PRR communication system. This causes close coupling between the two circuits with corresponding interference on the PRR communication system. This interference was so severe that some phases of the communication system were entirely disrupted.

Table III shows the frequency and harmonic currents existent on the power company's system as a result of the rectifier operation.

There were three possible ways of correcting this condition. One was to have PRR install conductor cable for the communication system. This was felt not advisable as it would require the installation of a large number of repeaters and other special equipment. Also there was a possibility that the train radio phone system, which operates at frequencies of 144.8 and 80 kc and requires an aerial which would ultimately tie in with the communication system, would still be a source of interference. A second solution was for Bethlehem to install filters at the outdoor sub-station. Such an installation would be quite costly, require a large amount of space and would have to be modified or added to if additional rectifiers were installed on the rod and wire mill system. The third method, and the one adopted, was to make changes to the power company's transmission lines.

Figure 21 shows the power company's system after

TABLE III
Division of Harmonic Current

Frequency	(A) Current Broad St. line, amp	(B) Current Seward line, amp	Ratio (A) to (B)
300	5.9	2.5	2.4
420	1.5	0.75	2.0
660	3.13	0.5	6.3
780	2.18	0.16	13.6
1020	0.33	0.032	10.3
1140	0.21	0.029	7.3
1380	0.33	0.041	8.1
1500	0.14	0.031	4.5
1740	0.19	0.047	4.1
1860	0.14	0.032	4.4
2100	0.19	0.042	4.5
2220	0.10	0.058	1.7

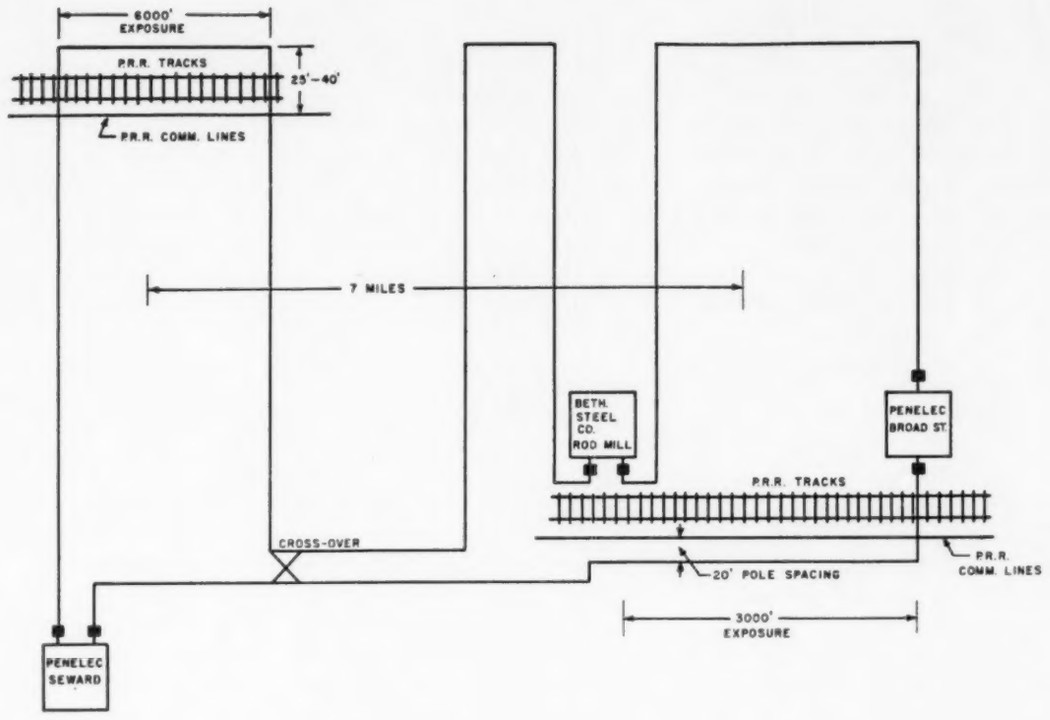


Figure 21 — Revised 23-kv power system which feeds rod mill.

the changes were made.

No interference has been experienced with telephones, radios or television equipment.

Another problem that has caused considerable concern is the action of the rectifier equipment during power surges. During a power surge and the voltage drops, the speed of the mill will drop along with the voltage without causing any undue disturbance. However, when the voltage returns to normal the rate of rise is very rapid, and since there is no inertia in the rectifier system, the motors attempt to speed up at the same rate as the rise of voltage. This causes overloading of the motors. In some cases the cathode breakers on the rectifiers opened along with the individual motor breakers, and in one case several mill spindles were broken. Serious delay to the mill resulted as in most cases it was full of steel when the fault occurred.

To overcome this situation, an under-voltage relay has been installed which goes into operation when the surge causes a drop in voltage greater than 10 per cent. The operation of this relay will disconnect all speed-regulating devices on the main drive motors, and drop the output voltage on the rectifiers to a preset value of approximately 100 volts. When the voltage rises, d-c voltage will remain at a maximum of 100 volts, thus it is possible to clear the mill of steel at a low speed. As soon as the mill is cleared, the operator restores the equipment to normal setup, and the mill is restarted and ready to roll again. In order to help this situation, the power company is expediting changes in their transmission system so that this mill will be fed from a separate transformer bank connected to the 115-kv system over a short 23-kv line.

The number of surges should be greatly reduced as disturbances on the 115-kv system are small compared to those on the 23-kv system to which the mill is presently connected.

This problem would not be serious on a "stiff" power system.

Discussion

PRESENTED BY

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A. J. White: The installation at Johnstown introduced for the first time three major advancements in the application of electric equipment to rod mills.

The first major advancement was a change in the basic system approach. The past philosophy of utilizing main drive motors with special impact special drop characteristics to roll satisfactory products was carefully examined. Motors with standard impact speed drop characteristic, combined with a speed regulator control system were compared to these special motors, with no regulators, through the means of the electronic analogue computer. The results of these studies indicated that it should be possible to roll satisfactory products with motors having standard impact speed drop characteristics, when combined with a new type speed regulator control system operating through the shunt field of the motor.

This new system was applied for each main drive in the roughing, intermediate and finishing mills. As Mr. Anderson has pointed out, this new system has rolled

very satisfactory products since the mill start-up over a year ago. Since that time this new system has been applied to other rod, merchant, and combination rod bar and merchant mills now in service, or going into service in the near future. In addition the speed regulator control system has been utilized for tube mills, along with motors having very special impact speed drop characteristic, to improve the over-all performance in relation to what had been realized previously.

Much of the success of this new system should be attributed to the engineering analysis utilizing the electronic analogue computer. Time response curves of the various systems considered were compared, and through this means, the correct control system design and component characteristics were evolved.

Every day the value of computer studies becomes more evident. We believe that the success of this new system points out the need for more computer studies for new system drives. Also, it points out the need for examination of old system drives to obtain more basic information to determine where changes can be made to improve performance.

At the Johnstown installation the computer served a dual purpose. Not only did it aid in determining the best speed regulator control system with the proper gain and stabilizing element for each motor; but it also provided resistor, capacitor and other setting which minimized tune-up time during installation. This was quite important at Johnstown since the time allowed for tune-up was very short. Actual tune-up of the roughing and intermediate mill drive systems was performed without the mill stands in place and during removal of the old mill. Several times during tuneup of the intermediate mill, it was necessary to shut down to allow for blasting, as the old mill stand foundations were removed. When the new mill stands were placed in position, and coupled to the motors, only minor adjustments had to be made to obtain optimum performance.

The second major advancement was the application of pumpless rectifiers as the main drive d-c power supply. Although pumpless rectifiers have been utilized as power supplies for other system drives such as hot strip mills, and skelp mills, this was the first application to a rod mill. In addition, a new voltage regulator was introduced. The characteristics of this new voltage regulator was such as to improve the transient response over what had previously been obtainable, and at the same time improve the regulating accuracy. This faster response time was desirable on this mill because of the existence of the speed regulations control system on each motor line. As Mr. Anderson has pointed out, each rectifier has sufficient phase control to adjust the output voltage from 595 to 700 volts under load as a normal operating feature. This is accomplished through a static magnetic phase shifting circuit of which the voltage regulator is a part. In addition, this circuit allows sufficient phase control to adjust the output voltage from 0 to 700 volts for bringing the motors from rest up to mill speed.

Mr. Anderson has pointed out one of the major advantages in the application of rectifiers in preference to motor-generater sets. This is the flexibility. At Johnstown the motor room was a house inside of the main building and was limited in amount of available floor space. As has been pointed out, the rectifiers, anode breakers, tanks, heat exchanger, excitation and control units were mounted above the rectifier transformer on a balcony, and therefore minimizing actual floor space area needed for the main drive power supplies.

Since the start-up of the Johnstown mill, pumpless rectifiers have been applied to merchant mills, combination rod bar and merchant mills now in service or to go into service in the near future. In addition, the new voltage regulator has become the standard not only for rod mills but for all other type of system drive utilizing rectifiers on non-reversing applications, such as hot strip, skelp and billet mills.

The third major advancement was the application of totally enclosed water to air-cooled d-c main drive motors. Mr. Anderson has discussed and illustrated this type of motor construction which integrally incorporated its own cooling and cleaning means as well as providing its own self-supporting foundation base. Mr. Anderson has pointed out that this design was utilized both to save time and reduce construction costs.

The time saving was especially important in the Johnstown installation since only 27 days change-over time was allotted between the shutdown of the old mill and start-up of the new mill. Utilization of the new type of motor construction eliminated any but the most minor change in existing foundation over which the motors were erected and allowed the motors to be put in place, checked out and run for tune-up ahead of the completion of installation of the new mill stands.

Since the Johnstown installation several other installations utilizing this motor construction have been ordered and are to be installed in the near future. These particular installations involved large reversing mills, and also a billet mill in which an existing steam engine drive is being replaced in the same physical location by six electric drive motors.

The economics for this billet mill are quite similar to the Johnstown installation in the savings of both time for change-over, and actual construction costs by not disturbing existing foundation.

Other installation cost reductions can be realized by this type of motor construction, depending on the particular installations, among which are some of the following:

1. Elimination of forms for concrete walls for foundation, plenum chambers, air tunnels, and so forth.
2. A decreased cost of material and labor for excavation, erection of foundations, plenum chamber, air tunnels, air locks, and so forth.
3. Elimination of the installation costs of ventilation equipment.
4. Reduced installation cost of rotating equipment resulting from package design of pre-assembled units and central terminal board.
5. Release of basement floor area for storage or in cases similar to the Johnstown installation, complete elimination of a basement except for cable tunnels.
6. A simplification of engineering drawing and planning.

The time factor is present in most of these points.

It is to be expected that the first cost of the totally enclosed water to air-cooled motors will be higher than that of the standard motor construction with covers for forced ventilation and separately mounted ventilation equipment.

However, the economics must be compared on the total installed cost considering all factors. It is to be appreciated that there are also intangible factors, upon which the purchaser must place his own dollar evaluation in arriving at the over-all economics of the installation. One of the most important of these is the reduced maintenance for the totally enclosed water-to-air-cooled construction over that for conventional designs. This is due to the isolation of each machine with its own integral ventilation and cleaning system. Adequate volume, temperature, and cleanliness of cooling air is always available to the machine. This will mean actual dollar saving in installation life.

In addition, this same feature will assure freedom from unbalanced air flow sometimes encountered in group ventilation systems. To obtain equivalent protection would require a number of additional fans (also coolers if recirculating), to be added to a conventional design.

This feature can well be appreciated for a rod mill layout such as Johnstown where there exist both, motors normally group ventilated such as the roughing, and part of the intermediate mill; and also motors removed from the main source of ventilating air, which must receive air at sufficient pressure through tunnels or ducts. This is perhaps one of the most difficult types of mills to provide adequate ventilation equipment and the utilization of this new motor construction can mean real installed cost savings.

H. H. Angel: The 23-kv cable applied has extra insulation which is a standard in many of our plants. We find this to be a good practice.

Every effort was made to keep the old rod mill shut down the minimum of time while changing over. Much of the new equipment was tried out before the mill was shut down.

Much thought was given to applying drive motors with the best over-all impact speed drop characteristics, consistent with first cost, and the improvements in techniques in motor design, regulators and computers. We believe the results to be good.

Much concern was felt as the mill design progressed, that the vision of the operators in the main pulpit might be somewhat limited due to the crowded conditions in the old mill. The final arrangement is considered quite satisfactory.

The telephone interference mentioned was quite pronounced and it is the first case in the installation of some 24 mercury arc rectifiers in Bethlehem Steel Company steel plants.

I might mention a word about the power factor. Most engineers know that the power factor of these rectifiers is lagging and varies from 80 to 90 per cent. In this case, everything was done to keep the power factor as high as possible. However, I believe in Johnstown we pay for all kilovars. The cost of all the kilovars varies from about one per cent to about two and a half per cent of the total power cost.

Certainly the installation of any correcting equipment would hardly be justified under those conditions.

A. F. Kenyon: It is interesting to note the many similar features of the Cuyahoga and Johnstown rod mills, even with two different operating steel companies and two different electrical manufacturers. Also of course there are many features which are different.

One thing of interest is that the three rectifier transformers in each case are controlled from a single high voltage circuit breaker. In some respects this might be likened to a motor generator set with one synchronous motor driving three generators supplying separate bus sections. It is now rather general practice for a single high voltage circuit to supply two or three rectifier transformers, with individual disconnecting switches to isolate any transformer in emergency.

Another feature of the Johnstown mill is the operation of the rectifier transformers directly from the 23-kv power supply. With a motor-generator set a stepdown transformer is required where the supply voltage is higher than 13.8 kv, whereas rectifier transformers may be connected directly to the supply up to 34.5 kv or even higher. In such cases the elimination of a stepdown transformer effects savings in first cost and operating losses which favor the rectifier installation.

We note that the rectifier transformers are compensated to maintain rated d-c voltage with 95 per cent of rated a-c voltage, and up to 125 per cent rated full load. On a hot strip mill or other mill subject to high peak loads, it is, of course, necessary to compensate the rectifier transformers to maintain full d-c voltage up to 175 per cent load. However on a rod mill, where the load is quite uniform and with no high peaks, it is satisfactory to compensate for only 125 per cent load, thus enabling operation with lesser average phaseback and hence high average power factor.

Mention was made that the jogging operation, particularly in the reverse direction, is limited to the usual low jogging voltage. On mills producing small rod from comparatively large billets, the roughing stands operate at very slow speed even when delivering finished rod at 6000 fpm. Then jogging at perhaps 5 or 7½ per cent of normal voltage, and with full field excitation on the motors, the speed of the roughing stands will be so extremely slow that a very long time is required to back out a cobbled bar. During early breaking-in operation, there was some desire from the mill operators to provide much faster jogging of the roughing mill drives. Since the mill has gotten into operation and cobbles in the roughing mill occur only infrequently, this need for high jogging speed has largely disappeared. I wonder whether such a condition might have occurred on the Johnstown mill, and whether such high speed jogging of the roughing stands should be considered for future mills.

The installation of the main drive motors in the mill building, with individual air cooling and recirculating ventilating equipment self contained in the motor base, is a departure from usual practice, and could be justified in the Johnstown installation, where the new mill replaced an old mill in the same area and the change-over time had to be kept to a minimum. For a completely new installation, it is questionable if this arrangement could be justified in comparison to a more conventional ventilation system.

Mr. Anderson has mentioned the problems which arose because of interference with parallel telephone lines, and the changes necessary to eliminate this trouble. Also Mr. Angel has commented that in some twenty-four rectifier installations in different plants of the Bethlehem Steel Co. this is the only one which caused any telephone interference and that its correc-

tion was relatively simple. This indicates that rectifiers may be installed and that it is only the remote case with large exposure to communication systems that interference trouble will show up.

E. L. Anderson: We have not experienced any trouble with our operators with slow-speed jogging.

D. C. Nelson: I believe that all will agree that the electrical equipment as described is quite a departure from the older rod mills, which in most cases, consisted of only a steam engine for the motive power, and is also quite different from the later mills with main drive motors and motor generators.

From the appraisal of rectifiers versus motor generator sets that have been adequately covered in previous AISE papers, with the information as given by Mr. Anderson in his paper, the advantages are definitely in favor of the use of rectifiers in respect to equipment cost, installation cost, and maintenance cost.

The disadvantages, such as the interference with the Pennsylvania Railroad communication system, and the trouble incurred due to power surges, do not seem to have been too difficult or costly to eliminate.

I have two questions I would like to ask Mr. Anderson on the information given. First, for the power at 250-volts, d-c for the various mill auxiliaries, cranes and so forth, provided by the rotary converters operating from the 25-cycle system, was any emergency source of 250-volt, direct current power provided for use in case of an outage on the 25-cycle system?

Second, on the figures given for the power consumption on average rolling and finishing out of No. 23 stand, was the power for crane and mill lighting included in the miscellaneous figures?

From the figures given, the over-all power required for average rolling and finishing out of No. 23 stand are 110.2 kwhr per ton.

We installed a rod mill in 1951 at our Aliquippa Works quite similar to this mill, the installation, mechanical and operating features were covered in the 1955 Proceedings AISE. This mill consisted of only 22 stands, as follows:

Eight roughing stands, driven in pairs by one 500-hp motor each pair, all from one 1500-kw generator.

Eight intermediate stands driven in pairs by one 800-hp motor each pair, all from one 2250-kw generator.

Six finishing stands driven by one 2000-hp motor from one 1500-kw generator.

Total connected horsepower for main drives is 7200 hp. Total generating capacity is 5250 hp.

A check on the power consumption on this mill for January, February and March, 1957, showed approximately 100 kwhr per ton for an over-all power consumption. Due to the diversified product rolled for these three months, the tonnage produced for this period was lower than normal production.

Figures on over-all power consumption for rod and bar mills have been stated as being 60 to 80 kwhr per ton (Electrical Engineering, Nov., 1956).

For modern up-to-date mills with more miscellaneous drives, the trend to more individual driven stands, and automation application in the steel mills, the trend is upward for the kwhr per ton processed, and it requires a careful study and analysis of the particular process involved to come up with the best solution to suit all conditions.

From the information and description in his paper, Mr. Anderson appears to have accomplished this.

E. L. Anderson: We have not found it necessary to provide any emergency source of 250-volt, direct current power for operation of the mill in case of an outage on the 25-cycle system. An outage on the 25-cycle system would cause a loss of air and the shutting down of the mill, and to be fully protected it would be necessary to include standby power for the 220-volt, 3-phase, 25-cycle, a-c power as well. We did not feel that this was justified as the operation of our 25-cycle system has been very reliable. The figures given do not include the d-c cranes. Since the amount of power used by these cranes is very small it would have little effect on the total power consumption.

Carl Degenhardt: Do the cables on the racks in the basement have fireproof insulation which would prevent a serious fire?

E. L. Anderson: The cables installed in the racks in the basement are of rubber insulation with neoprene jacket of voltage ratings as listed in the body of the paper. We did not consider fire-proof insulation a necessity. ▲

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Developments In Metallic Recuperators

Metallic recuperators are gaining acceptance in the United States . . . . users find them good performers . . . . manufacturers of the equipment argue design and installation details.

by Thomas E. Dixon, Vice President, and

Heinz A. Kuhne, Vice President, Griscom-Russell-Schack Co., Inc., Pittsburgh, Pa.

IN 1954, Emil Vierow ("Metallic Recuperators in the Steel Industry," AISE Yearbook p. 552) described the two principal metallic recuperators which were in general use in the steel industry of the United States at that time. In concluding, he suggested that a report on metallic recuperators in use in Europe might be of interest. The authors are grateful for this opportunity to present details of several designs of European recuperators. Certain of these designs, incidentally, have become established in the United States in the interim.

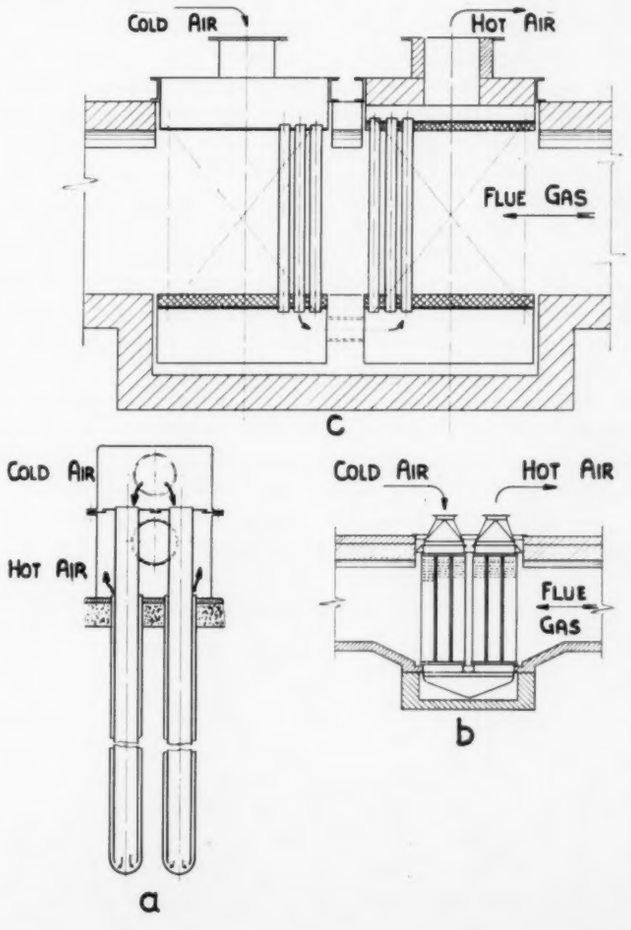
The units described by Mr. Vierow both have one major design feature in common with several European recuperators, and we have, therefore, reproduced schematically the principle used to transfer heat in these designs.

The recuperators described by Mr. Vierow are shown in Figure 1 at (a) and (b). In recuperator (a) the heating element consists of an outer tube suspended from a header box and an inner tube. The air to be preheated flows down the inner tube, then reverses its direction at the bottom to flow upward through the small annulus between the two tubes, and is collected at the top of the outer tube in a second header box. In the heat exchange industry, this design is sometimes known as the bayonet-type heater element. The flue gases flow around the outer surface of the larger tube.

In recuperator (b), the heating element consists of a finned casting. The flue gases flow around the finned surface, while the air flows inside the casting. The inside of the casting may also be finned.

A further example of a recuperator using the same principle is shown at (c). This design is used extensively in Europe. It was first designed some twenty years ago and has been applied in many hundreds of installations to preheat air, blast-furnace gas and other gaseous media. The recuperator is very similar to design (b) and consists basically of two tube bundles, each of which is suspended from a common framework, resting on top of a flue. Each bundle has a flanged header box and the lower ends of the bundles are welded into transfer boxes, which hang freely in the flue. These boxes can move up or down as the tubes expand or contract with changes in wall temperature. The transfer boxes are connected by convolute-type expansion joints, allowing for differential expansion between the two bundles. The tubes are usually set on a square pitch to facilitate inspection and cleaning. The tubes are of

Figure 1 — These sketches show several designs of flue type metallic recuperators.



seamless quality and their diameter varies to allow for changes in air velocity within the tube, to compensate in part for the effect of flue radiation on the first rows. Ferritic grade chrome steel, progressively reducing in its chrome content as the tube rows move away from the flue-gas inlet point is used as material for the heat exchange surface. The design also incorporates measures to prevent flue-gas short circuiting around the transfer boxes.

Consistent preheats of 1300 F on air and 850 F on blast furnace gas have been achieved without difficulty with this design, which has found its major application in the iron and steel industry in Europe.

As already stated, these designs all have one feature in common, namely, the heating element is located within a flue or ductwork lined with refractory brick. In all cases, the flue gases flow around the outside of the heating surface, while the air or gas being preheated flows inside the heating surface. For this reason, this recuperator is known as a "flue-type" recuperator. Each of the designs shown and several other derivatives employing the same principle of heat transfer have given quite satisfactory service on furnace applications of a continuous nature.

Following the success experienced with flue-type recuperators on continuous operations, and therefore under conditions in which the air and flue gas passes are fairly consistently loaded, several installations of the units (a) and (b), Figure 1, have been made on soaking pits in the United States. Early installations consisted primarily of a single recuperator designed to provide preheated combustion air for three- or four-hole soaking pit batteries. More recently, plans are afoot to use them on a single pit in order to facilitate better furnace pressure control and the control of the fuel-air ratio to the burner on the cold side of the recuperator. It might be interesting at this stage to examine certain aspects of recuperator design, more particularly those which apply to flue-type recuperators expected to operate under widely varying conditions of both temperature and volume on the air and waste gas passes.

It is apparent that if the temperature of the metal surface through which heat is being transferred can be kept to a minimum, other things being equal, recuperator life will increase. At high temperatures the physical characteristics of steel are reduced to a fraction of their value at room temperature, and steel has a tendency to creep. It is easily and permanently deformed by small loads. It is more susceptible to attack by chemicals carried in the heating gas, particularly when this gas varies between oxidizing and reducing conditions.

Hence, the problem to produce a high preheat, but simultaneously maintain an acceptable tube wall temperature. The formula for the tube wall temperature (assuming very thin metallic heat transfer surfaces) follows:

$$t_w = \frac{ht + h't'}{h + h'}$$

t_w = wall temperature
h = transfer coefficient of the heating fluid
t = temperature of the heating fluid
h' = transfer coefficient of the heated fluid
t' = temperature of the heated fluid

Tube wall temperature t_w is obtained by adding the product of h (transfer coefficient of the heating fluid) and t (the temperature of the heating fluid) to the product of h′ (transfer coefficient of the heated fluid) and t′ (the temperature of the heated fluid) and dividing this sum by the sum of h and h′.

If h and h′ are equal, t_w is the arithmetic mean between t and t′; in other words, the temperature of the tube wall lies exactly midway between the temperature of the fluids on either side of it. If we now make h equal infinity, then t_w equals t, i.e., the tube wall will be at the same temperature as the heating fluid, a condition which we wish to avoid. Conversely, if we make h′ equal infinity, the temperature of the medium being heated and the wall temperature will be equal.

But t and t′ are either specified or existent. Thus in order to obtain the desired wall temperature, one is first tempted to reduce t_w by making h′ high and h low. Though this approach might increase the recuperator's resistance to overheating, and therefore its life, it would not give the most economic design. Also, the heat transfer coefficient is proportional to the 0.75th power of the velocity,whereas pressure loss is proportional to the square of the velocity. Therefore, some acceptable compromise between initial recuperator cost and operating cost (i.e., power consumed in driving combustion air blowers and the like) must be found.

But even when we have found our compromise and adjusted h and h′ to give the desired value of t_w, conditions can arise, either through the manner in which a furnace is operated or due to a failure of control equipment, whereby changes in velocity can no longer have any effect on the rate of heat transfer. Under these conditions, the wall temperature can very easily reach dangerous proportions.

Figure 2 shows on the left a typical flue-type recuperator, falling under the categories (a), (b) and (c), shown in Figure 1. The first rows of the tubes are subject to the direct radiation of both the flue brickwork and the radiating components of the flue gas. The flue may be considered as a black body radiating through an opening corresponding to the nest of tubes or heating elements. Under these conditions, the quantity of heat transferred from the flue and gas to the heating element follows the Stefan-Boltzmann law for which the formula is:

$$\Phi = \epsilon\sigma A\,[T_1^4 - T_2^4]$$

Φ = heat flow by radiation
ϵ = emission factor
σ = Stefan-Boltzmann constant
A = area of surface
T_1 = absolute temperature of radiating body
T_2 = absolute temperature of irradiated body

The flow of heat due to radiation is seen to depend upon an emission factor, the Stefan-Boltzmann constant, the area of the radiating surface, and the difference between the absolute temperature of each of the bodies raised to the fourth power. For any given set of circumstances, the heat flow per unit of area and time will thus depend upon the temperature of the radiating and the irradiated bodies. There is no direct reference in this formula to any function of gas velocity.

One is tempted to think that, by increasing the rate

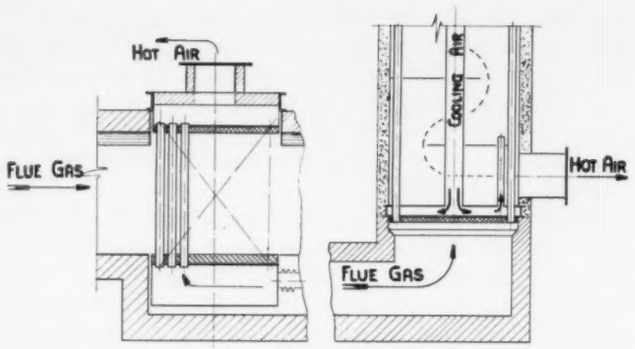


Figure 2 — Sketch to left shows typical flue type recuperator installation. To the right is a tubular installation.

of heat transfer within the tube, T_2 might be influenced sufficiently to keep the wall temperature down, but in practice this is very hard to do. The following calculations will illustrate this:

Flue Type Recuperator

(a) Normal operating conditions

Assume $h' = 16$ Btu per sq ft, hr, F
$h_c = 8$ Btu per sq ft, hr, F
$t = 1700$ F
$t' = 1000$ F
$t_w = 1470$ F

$q_c = 8\ (1700 - 1470) = 1840$ Btu per sq ft, hr
q_{rad} (assume $\epsilon = 0.9$) $= 11{,}700$ Btu per sq ft, hr
$\frac{2}{3}\, q_{rad} + q_c = 9{,}640$ Btu per sq ft, hr

$$h = \frac{9640}{1700 - 1470} = 42 \text{ Btu per sq ft, hr °F}$$

$$t_w = \frac{42 \times 1700 + 16 \times 1000}{42 + 16} = 1500 \text{ F}$$

(b) Overheating in flue

$t = 2150$F
Assume $t_w = 1950$ F

$q_c = 8\ (2150 - 1950) = 1600$ Btu per sq ft, hr
q_{rad} (assume $\epsilon = 0.9$) $= 20{,}000$ Btu per sq ft, hr
$\frac{2}{3}\, q_{rad} + q_c = 14{,}800$ Btu per sq ft, hr

$$h = \frac{14{,}800}{2150 - 1950} = 75 \text{ Btu per sq ft, hr, °F}$$

$$t_w = \frac{75 \times 2150 + 16 \times 1000}{75 + 16} = 1950 \text{ F}$$

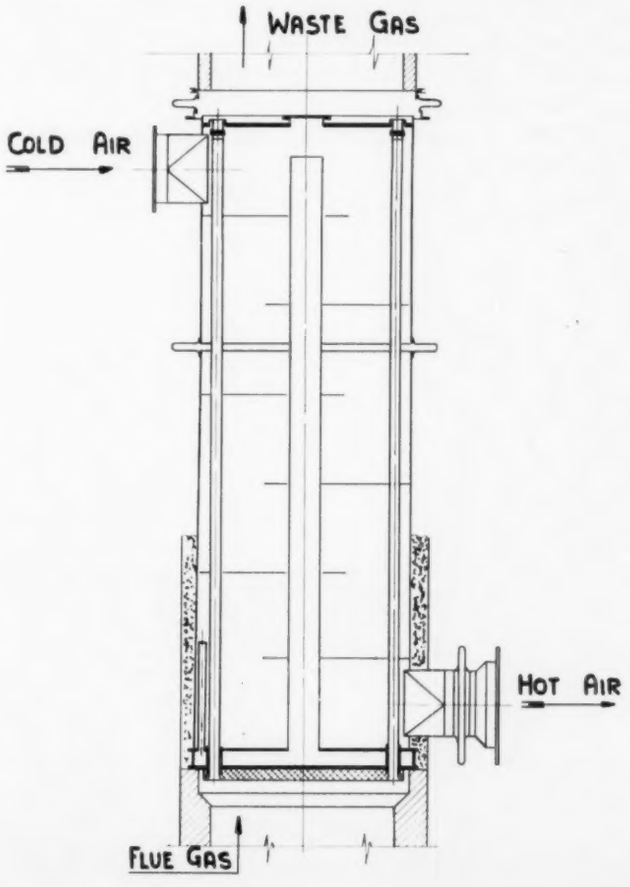
The heat flow due to convection q_c, using the conditions chosen, amounts to 1840 Btu per sq ft, hr. The heat flow due to radiation q_{rad}, using ϵ equal to 0.9, will be 11,700 Btu per hr. Some of this heat is reradiated to the following rows of tubes and we will assume, therefore, that only two-thirds of this quantity, or 7800 Btu per sq ft, hr is transferred to the first tube row by radiation. Thus the total heat transferred due to radiation and convection is 9640 Btu per sq ft, hr. The heat transfer rate between the flue gas and the tubes is 42 Btu per sq ft, hr, °F, resulting in a wall temperature of 1500 F, which closely approaches the wall temperature assumed at the beginning of the example.

If the flue gas temperature rises suddenly to 2150 F, due perhaps to a failure of the furnace temperature control or dilution air-control, or to after-combustion, the heat transferred due to radiation is almost doubled. Using the same basis of calculation, a wall temperature of 1950 F results.

The formula for wall temperature shows that an enormous increase in h′ is required to bring the tube wall temperature down to acceptable limits. But, in trying to increase h′, difficulties are encountered with pressure drop. It will be recalled that heat transfer by convection inside a tube is a function of approximately the 0.75th power of the fluid velocity, whereas pressure drop varies with the square of the velocity. Thus, to increase h′ by 50 per cent, the velocity must be increased by 70 per cent, and in so doing the pressure drop across the air pass is tripled. Even this has very little effect on wall temperature, as a study of the formula will show.

In order to minimize the deleterious effects of flue radiation and to provide a unit capable of operating on very dirty flue gases, a recuperator was developed in Europe shortly after World War II, along the lines shown in Figure 3. This recuperator consists essentially of a cylindrical bundle of tubes within a metal shell, mounted vertically above the flue. The flue gases flow upwards inside the tubes, while the air flows in countercurrent around the tubes, being guided by a series of segmental baffles. By taking the heating elements (the tubes) out of the flue, they are removed from the radiating field. The tube sheet in which the lower ends of the tubes are welded is protected by a substantial layer of ramming refractory and is cooled in many cases on the

Figure 3 — Sketch showing design of tubular recuperator.



inside by a stream of cold air, using a double tube sheet. The angle subtended between the inside of the tube and the base of the flue is limited by the tube diameter, and direct radiation cannot enter the tubes. The unit has floating baffles and a differential system of expansion joints in the shell and on each tube, permitting differential tube expansion. Cleaning is a relatively simple matter by rodding through the tubes either from above or below.

Using the same figures for heat transfer, and the same flue gas inlet and air preheat temperatures, calculations for this recuperator show the following:

(a) Normal operating conditions

Assume $h' = 16$ Btu per sq ft, hr °F
$h = 8$ Btu per sq ft, hr, °F
$t = 1700$ F
$t' = 1000$ F

Radiation is negligible.

$$t_w = \frac{8 \times 1700 + 16 \times 1000}{8 + 16} = 1230 \text{ F}$$

(b) Overheating in flue

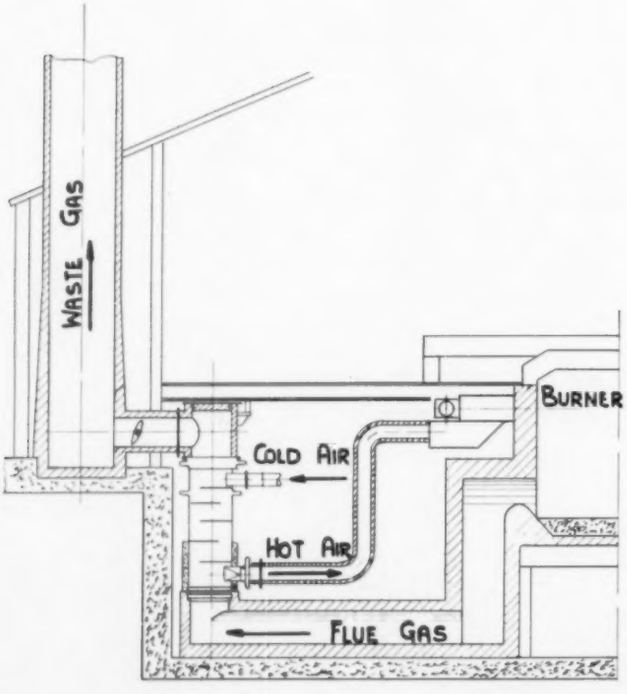
Assume $t = 2150$ F

$$t_w = \frac{8 \times 2150 + 16 \times 1000}{8 + 16} = 1480 \text{ F}$$

Under normal operating conditions, due to the negligible effect of radiation, t_w is only 1230 F. When the flue is suddenly overheated, the wall temperature rises to 1480 F. Thus, a margin of safety is provided by the location outside the flue. The tubular unit may be used even on a one-recuperator-per-hole basis without the need for a hot-air bleed. Protection usually consists of diluting the flue gas temperature to a normal figure of 1850 F, plus the provision that, in the event of a power failure, the stack draft is closed off.

A typical installation of a tubular recuperator on a soaking pit is shown in Figure 4. With preheats up to 1400 F, the length of this unit is such that it can be accommodated between the foundation pad and the operating platform. Little floor space is required, the largest diameter yet designed for a four-hole soaking pit battery, each pit being rated at 35,000,000 Btu per hr, was only 8 ft 6 in.

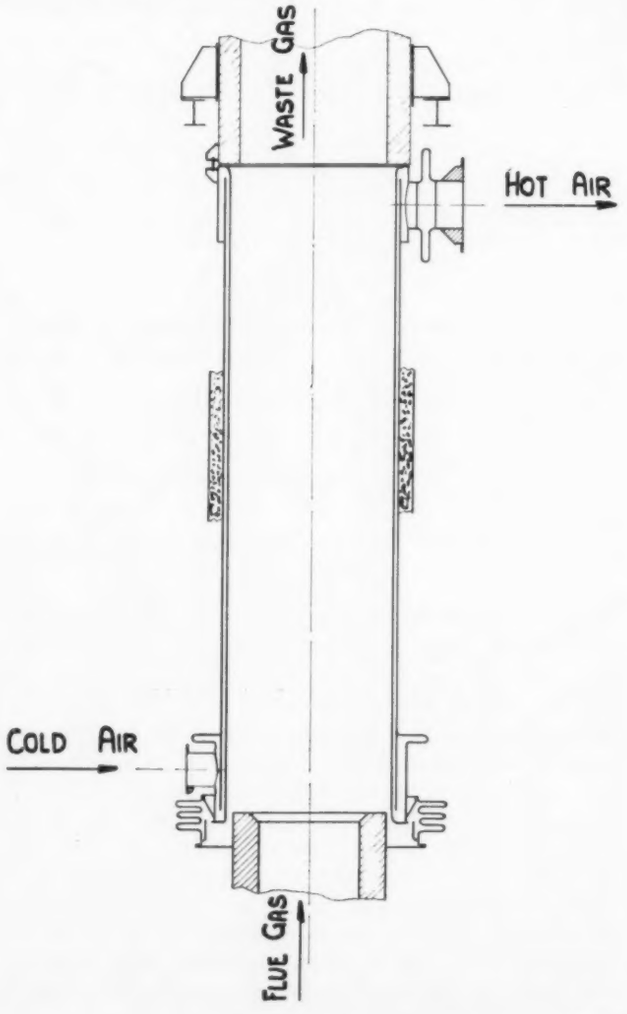
Figure 4 — Typical installation of tubular recuperator on soaking pit.



All recuperator designs familiar in the United States depend primarily upon convection to transfer heat from the waste gas to the medium being preheated. Their application is usually limited to entry temperatures of about 2000 F maximum. But there are frequent occasions where it is desirable to accept much higher temperatures than 2000 F. On a single soaking pit, for instance, the temperature of the waste gases leaving the pit can exceed 2300 F. On a continuous butt-weld furnace, temperatures may even reach 2600 F, and the flue gas is extremely dirty.

A. Schack discovered, as long ago as 1923, that certain components of flue gases, namely water vapor and carbon dioxide, radiate heat within the infrared band. His observations were subsequently confirmed by H. C. Hottel and others, who evolved methods to calculate the influence of gas radiation. This fact is used in the so-called radiation recuperator, a typical design of which is shown in Figure 5.

Figure 5 — The "radiation" recuperator consists of two concentric metal cylinders, with air flowing in the narrow annulus between them.



This recuperator consists of two concentric metal cylinders, having a narrow annulus between them. The recuperator is usually mounted above the flue in a vertical position, as in the case of the tubular design. The circular duct formed by the inner cylinder is used to carry the flue gases, while the air being preheated flows in the narrow annulus between the two cylinders. Since the heat is transferred from the flue gas to the inner cylinder by radiation, flue gas velocity is of no consequence, and this design involves practically no pressure drop on the waste gas pass.

In the air pass, heat is carried away by convection by driving the air at high velocity through the annulus. By using parallel flow in this design, that is, by introducing the cold air at the base of the unit at a point where the flue gases are hottest, it is possible to accept flue gas entry temperatures up to 2700 F without dilution. Very high heat transfer rates per unit area can be achieved. Many recuperators of this type are now being installed in England on single-hole soaking pit installations. Typical layouts are shown in Figure 6, where one stack is being used to draft several holes.

Figure 7 shows a radiation recuperator equipped with its own stack, which can be a very lightweight affair. This may be a means of saving considerable expenditure on the more conventional stacks with their heavy foundation.

The radiation recuperator has certain disadvantages if one is looking for the ultimate in heat recovery. This is due to the fact that the exit temperature should exceed 1300 F. Also, the heating surface which can be built into this design is limited.

This recuperator can, however, be very easily combined with the tubular unit described earlier, circumventing the shortcomings of both designs. Uniting the two gives an installation capable of providing maximum preheat and the maximum of safety in operation. The radiation section permits the admission of flue gas temperatures as high as is likely to be found, without the use of dilution air, while the tubular section may be designed to provide a large heating surface. Figure 8 shows a side-by-side arrangement of a radiation and a tubular recuperator.

There are several installations of this kind in Europe in use on hot-blast cupolas, where they are providing preheats of 1350 F for cupola wind. On these cupolas, the gas is very dirty, containing about 100 times as much dirt as precipitator cleaned blast-furnace gas, and yet this recuperator handles the cupola gas, which is burned near the base of the radiation unit, without difficulty. In some plants, owing to space limitations, a tower-type arrangement, in which the tubular recuperator is mounted above the radiation recuperator has been found very convenient. This arrangement is shown schematically in Figure 9.

Radiation recuperators can also be used in a tower-type manner, as is shown in Figure 10. In the lower recuperator, air is arranged to flow in parallel with the flue gas, and in counter-flow in the upper unit. The hot air emerges at the midway point. There are also examples of tubular recuperators being used in Europe in the tower arrangement. The lower recuperator is usually used to preheat combustion air, while the upper unit preheats blast-furnace gas. The flue gas temperature, on leaving the gas recuperator, is usually so low that it can be handled easily with an induced-draft fan having a carbon-steel impeller.

The latest design, in which the radiation recuperator and tubular recuperator are combined in one unit, is shown in Figure 11. This recuperator is known as the combination-concentric design. The radiation recuperator in the center is surrounded by an annulus of tubes.

Figure 6 — Typical installation of "radiation" recuperator on soaking pit.

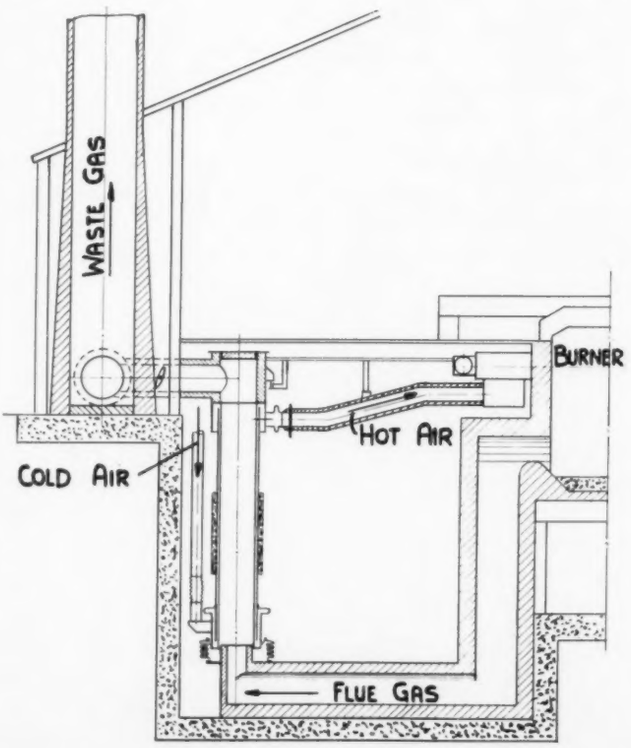
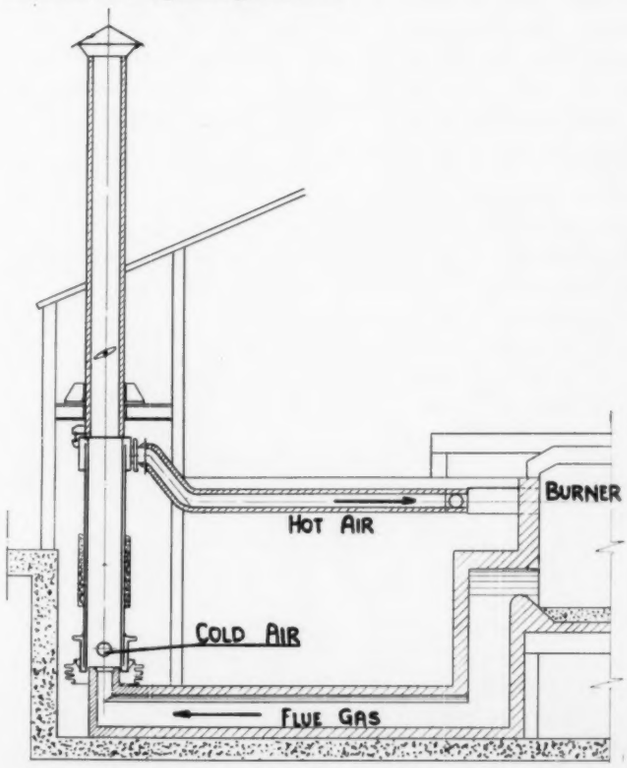


Figure 7—The "radiation" recuperator can be installed with its own lightweight stack.



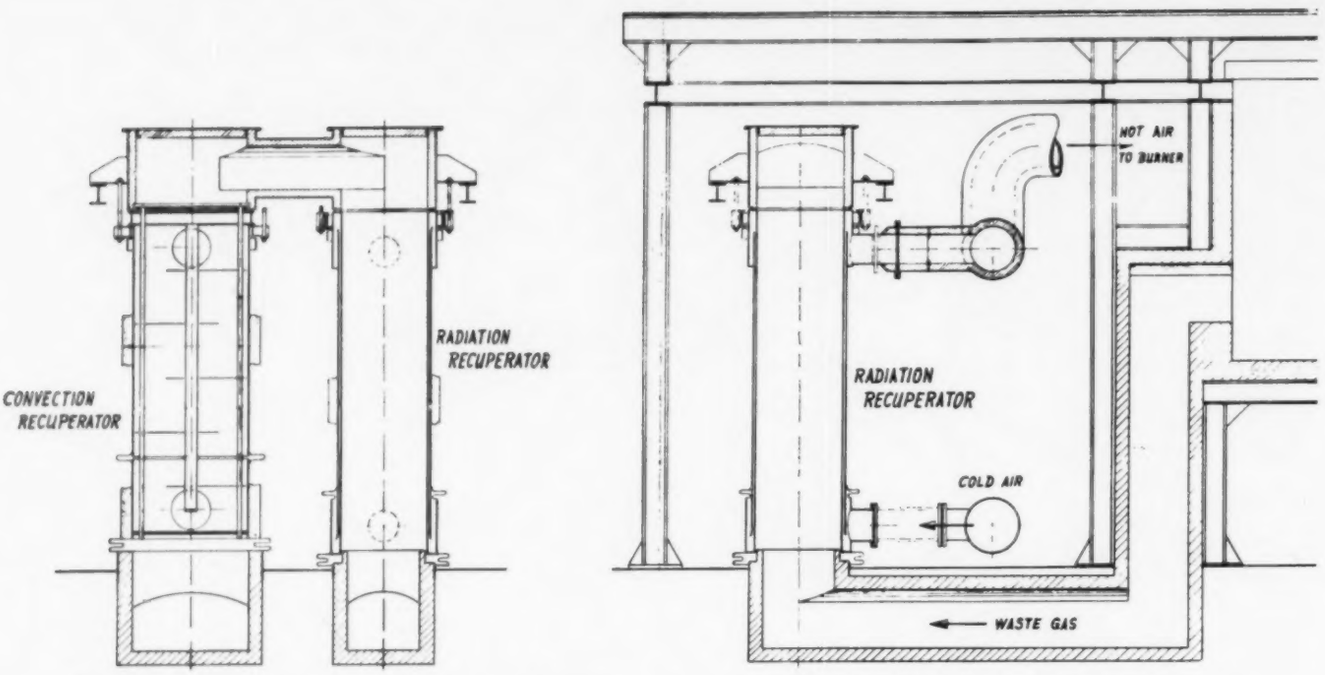


Figure 8 — A "radiation" recuperator and a tubular recuperator may be combined in series, as shown here.

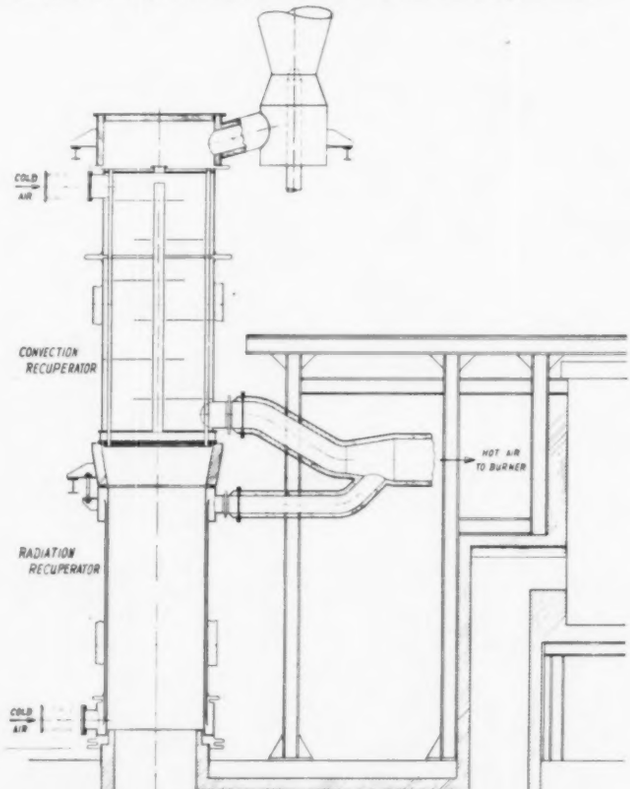
The flue gas enters the base of the radiation section and flows upwards through the inner cylinder. On reaching the top of the unit, it reverses its flow, entering the annulus of tubes at the top and flowing downwards inside the tubes. The flue gas finally leaves the recuperator near the base of the unit. The air to be preheated also enters the unit near its base and flows upward around the outside surface of the inner cylinder and through the tube nest. It finally leaves the recuperator at the top. The cold air, in relation to flue gas flowing in the inner cylinder, is in parallel flow, but it is countercurrent to the flue gas flowing inside the tubes. This is a similar arrangement to the side-by-side and tower designs. Also important, the lower ends of the tubes, where the waste gas is leaving the recuperator, are relatively cool and the hot section of the inner cylinder can re-radiate heat to these tubes. One of these units has been in operation now for four months. It is used to provide combustion air for a single-hole soaking pit fired with blast-furnace gas. The recuperator precedes another tubular recuperator used to preheat the blast-furnace gas. Figure 12 gives a series of temperature curves taken on this recuperator. There is no flue gas dilution and fuel-air ratio control is on the cold side of the recuperator.

The curve of air preheat climbs slightly from 1350 to 1470 F at the end of the heating cycle. The fuel input meanwhile has dropped from a maximum to a minimum. The blast-furnace gas preheat averages about 830 F and the waste gas temperature, after the gas recuperator, is less than 600 F.

Thus far, only recuperative methods for preheating combustion air and gas have been discussed. There are occasions, however, where recuperation cannot be used and direct-fired air preheaters must be used. A typical example of this is "stove stretching," an idea which has been evolved to increase the preheat available from blast-furnace stoves. Figure 13 shows a direct-fired preheater designed for this duty.

The preheater consists basically of a combustion chamber connected to a cylindrical vertical shell housing a large tube bundle. The products of combustion, after flowing along the connecting flue, enter the base of the shell and flow around the outside of the tubes and upwards through the shell via a series of baffle

Figure 9 — This combination of "radiation" and tubular recuperators places the units in a tower arrangement.



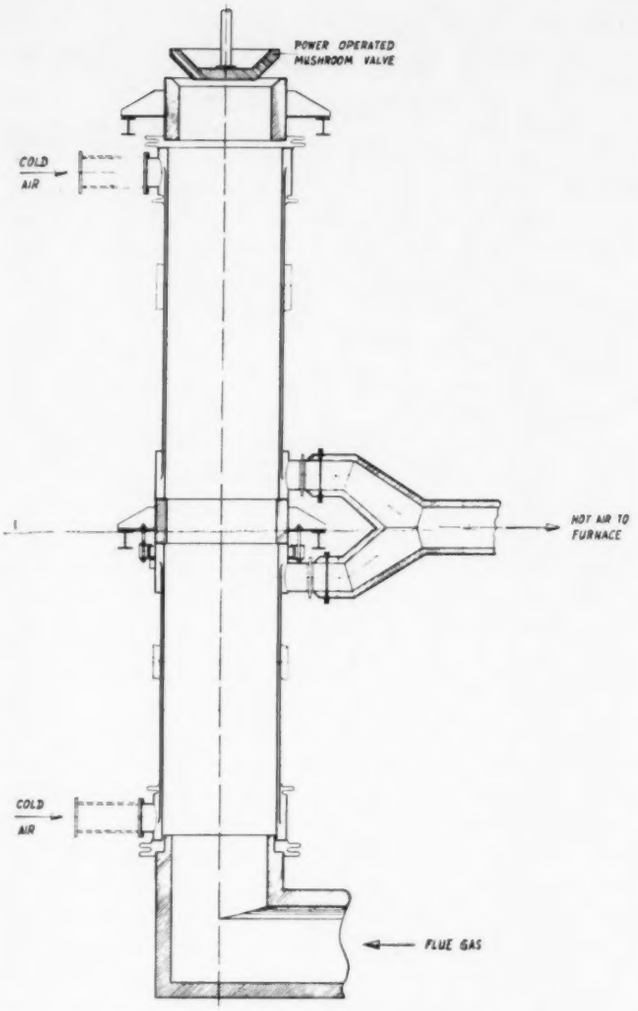


Figure 10 — The tower arrangement uses two "radiation" recuperators. This layout is also used with one unit heating air, the other heating gas.

plates. The waste gases are exhausted by means of an induced-draft fan near the top of the unit. The air to be preheated enters the top of the main bundle and flows in counter-current inside the tubes and is collected at the base of the unit. In order to protect the main tube bundle, an auxiliary heating suface is located between the combustion chamber and the tube shell. A small proportion of the wind flows in parallel flow through this auxiliary heater and joins the main stream at the common-wind line. The main heater bundle is fixed at its base and is counter-weighted at the top in order to relieve the tubes of their own weight when at temperature. Without this provision, the tubes would tend to sag. The preheater is equipped with a fuel-air ratio control to the burner, dilution-air control to reduce the flue-gas temperature within the combustion chamber to the desired value and automatic air preheat control. The unit is also equipped with suitable facilities for back-drafting. This design is currently being fabricated for use on a low-shaft furnace and will produce a preheat of 1450 F at approximately 8 psi pressure. Other preheaters of this kind have been built to provide hot wind at pressures up to 20 psi for iron blast furnaces of 500 tons capacity. Capacity in this design is simply a matter of paralleling a number of heaters of optimum size.

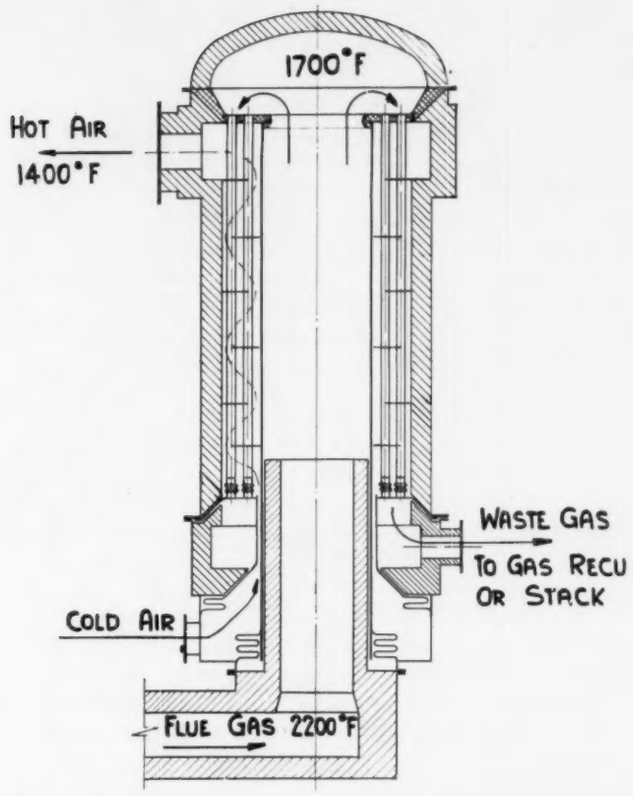


Figure 11 — A more recent concentric design combines a "radiation" recuperator and a tubular recuperator in one unit.

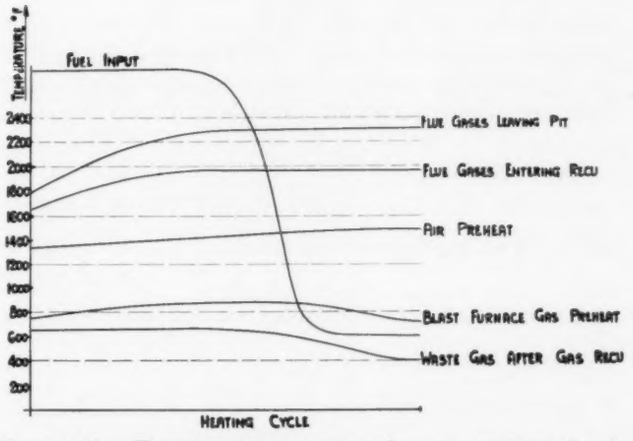


Figure 12 — Temperature curves taken on concentric air recuperator and a tubular gas recuperator in series.

There are other applications, particularly in the chemical industry, where air and gases such as oxygen and methane must be preheated to high temperatures at high pressure. In such instances, the heating surface often takes the form of helical coils housed within a refractory-lined shell. Such a preheater is shown in Figure 14. The radiation principle is again used here in conjunction with convective heat transfer with counter-current in one part of the preheater and parallel flow in another part. Heat is provided by burning a suitable fuel at the burner in the base of the preheater. The products of combustion rise through the unit and are exhausted by some suitable stack design at the top. The gas to be preheated enters the convection section at the top of the unit and flows in counter-current to emerge at the transition piece. The partly preheated gas

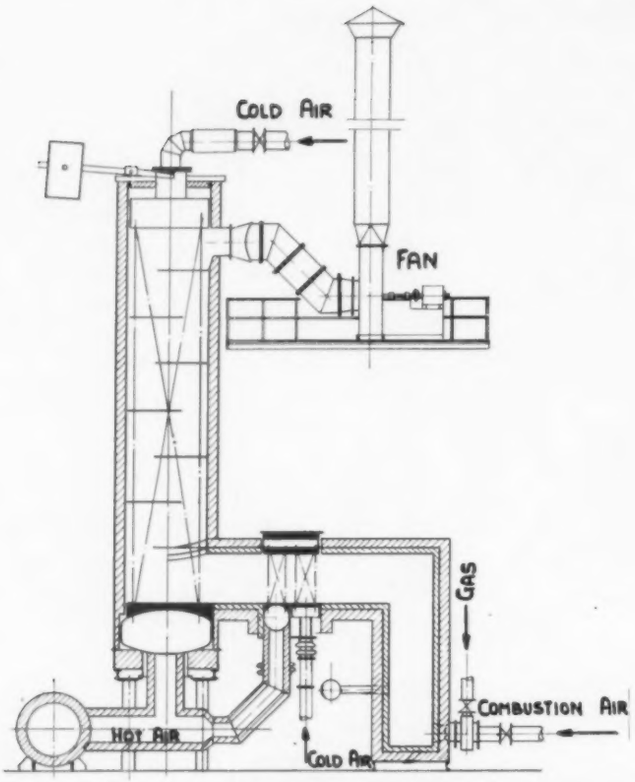


Figure 13 — Direct-fired preheater designed to increase preheat available from existing blast furnace stoves.

then enters the base of the radiation section and flows in parallel-flow towards the middle of the preheater. Many heaters of this kind have been designed to preheat pure oxygen and natural gas to 1250 F at 35 psi for use in synthetic acetylene plants. Other designs have been projected to preheat air to 1300 F at 300 psi.

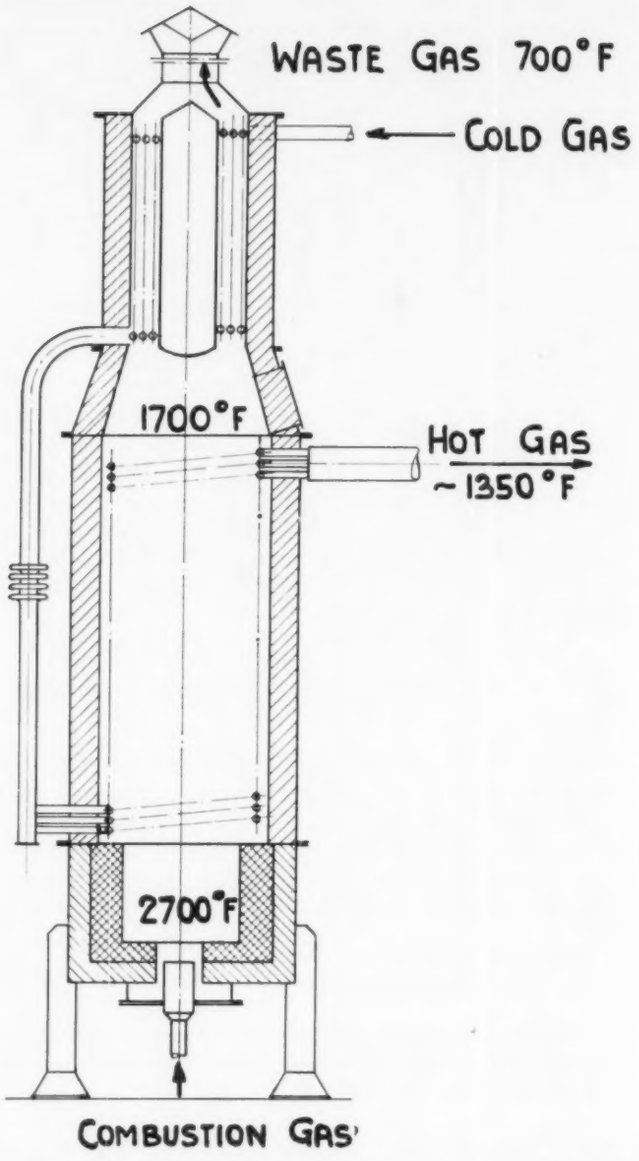


Figure 14 — This preheater, designed for the chemical industry, combines the radiation principle with convective heat transfer.

Discussion

PRESENTED BY

W. TRINKS, Associated Engineers, Inc., Pittsburgh, Pa.

J. D. KELLER, Associated Engineers, Inc., Pittsburgh, Pa.

T. E. DIXON, Vice President, The Griscom-Russell-Schack Co., Inc., Pittsburgh, Pa.

F. D. HAZEN, President, Hazen Engineering Co., Pittsburgh, Pa.

R. A. LAMBERT, Superintendent Steam Efficiency and Combustion, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

W. Trinks: The tubular recuperator is a well designed piece of equipment. However, flue-gases in tubes are not new. About 50 years ago, an American furnace builder placed flue type recuperators under the cold ends of their continuous furnaces. Most of those recuperators were burned out and finally taken out altogether.

These recuperators had three faults. The method of taking care of expansion was very ingenious, but did not work. The tubes were made of mild steel and were destroyed by heat, and the recuperator was so located that replacing any tube required tearing the furnace down. The modern tubular recuperator avoids these three pitfalls.

However, the old recuperator had one good feature. At the top of each tube, where the hot gases enter, a sleeve or ferrule was arranged, which was put there for the express purpose of being burned away. At the point where the flue gases enter, a very thorough mixing takes place, which promotes secondary combustion with flash heat.

In the new recuperator the same flash-heat occurs at the bottom, where the products of combustion enter. The bell-shaped tube, which is encased in refractory material, must be made of an expensive, creep-resisting and corrosion-resisting alloy. In other respects, no fault can be found with the well designed modern recuperator.

I have seen many of these recuperators in operation, including a hot blast heater for a blast furnace. In my opinion, there is a place for these recuperators in the United States.

J. D. Keller: This paper illustrates the various

designs of recuperators and heaters which have been used in European practice. Some of the statements made and inferences drawn, however, require criticism. For example, the authors' treatment of radiation as it occurs in actual flue-type recuperators is rudimentary and incorrect. Actually, there is a complicated interaction of radiation and re-radiation to and from various parts of the flue walls, the solution of which requires the use of integral equation (Hottel and Keller, Transactions, American Society of Mechanical Engineers, Volume 55, December 15, 1933, pages 39 to 50). Radiation from the brick work does beyond question increase very considerably the heat transfer of the front of the first row of tubes in the flue type recuperator, but to a much smaller extent than Mr. Dixon and Mr. Kuhne state. To a fairly close approximation, the increase can be calculated by the use of the broken-line curve in Figure 39 on page 36 of Trinks Industrial Furnaces, volume I, 4th edition.

It must be remembered, first, that the brickwork itself does not generate heat, but can only radiate heat to the tubes if it has first received that heat from the gases by convection or by gas radiation or both. Hence the brickwork must be at a lower temperature than the gases. Second, the closer any part of the brick radiating surface is to the tubes, the lower is its temperature, because the nearby parts subtend the greater part of the geometrical solid angle through which radiation to the tubes occurs. Thus the comparatively cold tubes cool off the adjacent brick surfaces greatly.

A fair average ratio of the heat transfer coefficient by radiation from gases plus the brickwork of the flue walls to the front of the first row of tubes, is about 2.5 to 1. When convection heat transfer from the gas is included, the ratio of the total gas-side coefficient becomes about 1.75 to 1. Contrary to the authors' impression, the increased radiation is easily taken care of in the double-tube type of recuperator. This is done by increasing the width of the annulus (referring to the double-tube design as in Figure 1a) at the front only of the first row of tubes. This has two good effects: first, it considerably decreases the air temperature (the authors' t), since much more air flows through the wider annulus; second, it increases somewhat the air side heat transfer coefficient.

Another thing that must not be forgotten is the helping effect of the inner tube. This receives heat by radiation from the outer tube, and transmits that heat by convection to the air flowing both inside the inner tubes and in the annular space between it and the outer tube. Since radiation goes as the difference of the fourth powers of the absolute temperatures, the inner tube at low temperatures helps only moderately in abstracting heat from the outer tube, but as the temperature increases, its helping effect goes up by leaps and bounds, so that before any dangerous metal temperature is reached, it is increasing the already high convection heat transfer coefficient by 60 to 75 per cent, consequently reducing the temperature of the outer tube in proportion.

In designing other types of heat transfer equipment using plain (not double) tubes, the writer sometimes tends to forget this effect and is then brought up short by the realization of just how much the heat transfer coefficient is reduced by the absence of an inner tube.

It is necessary to contradict explicitly the authors' statements as to the result of a sudden rise in flue gas temperature. They assume that the temperature of the refractory walls of the flue instantaneously rises to the full temperature of the gases. Actually, as is well known, refractories always lag behind the gases, either in heating up or cooling down; they act as a "thermal-flywheel." The heat transfer to the tubes then, immediately after sudden change, is that corresponding to convection plus gas radiation at the new higher temperature, plus radiation from the solid brick surfaces at the lower original temperature. Only after many minutes does the refractory temperature rise enough to increase the radiation appreciably.

Therefore, the theory of danger due to *sudden* increase of flue gas temperature falls to the ground. From the practical standpoint, the continued successful operation of well designed recuperators of this type over long periods without failures shows that the alleged danger of excessive metal temperature has no basis in fact. Actual metal temperatures have been measured by bare-junction thermocouples peened into the tube metal, and in no case did the temperature so measured approach anywhere near the critical temperature as regards strength or oxidation-resistance of the metal.

Furthermore, an important recent improvement in the control of these recuperators insures that the full maximum quantity of air will flow through the front tubes (those exposed to radiation from the refractories) at all times, regardless of the amount of turn-down of the burners on the furnace.

With reference to the question of pressure drop in relation to coefficient of heat transfer on the air side, it is well known that one gets only what he pays for. In other words, for a given pressure drop the heat transfer, other things being equal, will be roughly the same regardless of the kind or arrangement of the heat transmitting surfaces. There is, however, a difference between European and American practice. In Europe, where fuel and power are expensive, saving of power is a prime consideration, and an air-side pressure drop in recuperators of about 2-in. water column seems to be preferred. In the United States, fuel and power are less expensive, and production is the chief consideration, with freedom from shut-downs a close second. Under these conditions, an air-side pressure drop of 5 in. of water or even more, is acceptable.

The air-side heat transfer coefficient, with pressure drops of this order, is so high that the "bottle neck" as regards heat transmitting capacity is on the waste gas side, and not at all on the air side except possibly in the few cases where the gases are drawn through the recuperator by high induced draft. The reason for this is that the velocity of the gases is limited to that which can be produced by the excess or unused part of the natural draft of a stack of reasonable height. The available draft usually amounts to about ½ in., seldom to more than ¾ in., water column.

And the use of larger or smaller tubes has little effect on the gas-side coefficient; with smaller tubes the gas-side convection coefficient is increased but the gas-radiation coefficient is decreased, so that the net change is almost zero.

Since the air-side coefficient is usually about 2.25 times the gas-side coefficient (the authors' h′ about

2.25 times their h), the average metal temperature is kept desirably low, being closer to the air temperature than to the flue-gas temperature about in the ratio of 30 to 70 per cent.

The writer always thinks of the recuperator shown in Figure 3 as the old design brought out by G. D. Mantle in 1923. This recuperator was efficient and successful, though it is no longer manufactured. Its maintenance cost was fairly high, due to occasional burning-out of the tube sheet and the bottom ends of the tubes.

In the design shown in Figure 3, it is true that little heat is transmitted to the tubes by radiation from the refractory walls of the flues. On the other hand, the increase of velocity, and the contraction and subsequent re-expansion of the jet as the gases enter the tubes, cause turbulence and eddies which not only increase the convection heat transfer here but also provide the best conditions for localized secondary combustion.

This is probably the reason for forcing cold air across the lower ends of the tubes, but the length of the section thus cooled seems to be too short to drop the temperature of the gases sufficiently to protect the section immediately above, which is exposed to the hottest air.

Furthermore, when the furnace burners are turned down, the air flow is decreased in proportion and heat abstraction from the tubes is greatly reduced, while in soaking pits the entering gases reach their highest temperature at that time.

Finally, the lowest parts of the tubes, shown flared in Figure 3, projecting downward below the cold-air section, are not cooled at all (except by upward conduction through the metal, which is negligible), and can reach practically the full temperature of the entering gases in which some after-burning may be going on. For these reasons, even with the tube sheet covered with refractory, the fire-tube design may not be as safe as the authors state. And if the lower ends of the tubes fail, it probably means replacement of the entire tube-bank.

Coming now to consideration of soaking pits, these furnaces have certain characteristics peculiar to themselves and independent of the type of recuperator used on them. The authors' curves in Figure 12 may be correct for blast-furnace gas and for recuperators heating both the gas and the air, but in American practice using rich fuels, such as coke-oven gas or natural gas, the variation over the heating cycle of the fuel input and especially the temperature of the gases entering the recuperator is even greater than shown in Figure 12. What this means is that, in the early part of the cycle, when large quantities of very hot air are desired for combustion, the temperature of the gases available is too low to heat the air to more than a moderate temperature. Incidentally, to heat the air to 1350 F at the start of the cycle, with gases entering at only 1650 F as in Figure 12 a "pick up" ratio of 82 per cent would require an extremely large recuperator.

On the other hand, in the later or soaking part of the cycle when the hottest gases are available, only a small quantity of air is needed, and it should not be too hot.

These conditions are inherent, and cannot be changed by any type of recuperator applied to the pits. The obvious way to even things out, since soaking pits consist of batteries of three or more holes each, is to use one recuperator per battery, rather than a unit for each hole. The cycles for the different holes being staggered, a sufficiently large quantity of gases at sufficiently high average temperature is then always available to heat the required air to a fairly high uniform temperature when and as needed for each hole.

The drawback, in present installations, is in the control of the draft by a single damper between the recuperator and the stack. This means that when the cover of one hole is lifted to charge or remove ingots, cold air can rush into this hole and through the flue to the recuperator, not only reducing the gas temperature but also affecting the regulation of the other holes.

The writer has maintained that the final solution requires the development of a durable hot-valve or damper for each hole, which will not absorb much heat but still can withstand the high temperatures when placed in the flues between the outlet of each hole and the recuperator.

On the other hand, there are many soaking pits about the country equipped with a separate tile recuperator for each hole. Usually the tile recuperators are in bad condition and call for replacement, but because of space limitations it is often impossible to install a combined recuperator for several holes. In each case, a metallic recuperator can be applied to each hole and still be more satisfactory than the tile recuperator it replaces.

Figure 12 is correct in showing the great drop in temperature of the flue gases which occurs between the outlet from the pit and the entrance to the recuperator. The writer well remembers the trepidation with which steel plant engineers, about seven years ago, first approached consideration of all-metallic recuperators for soaking pits, as it was almost universally believed at that time that the gases would enter the recuperator at not less than 2300 F. As usual, no actual measurements were available, and the opinions were based on conjecture. Shortly thereafter, actual tests using aspiration pyrometers were made on pits in a number of different plants. They showed that the temperature of the gases dropped surprisingly fast after leaving the pits.

Even at a distance of not over 25 ft from the waste gas outlet of the pit, the temperature of the gases never reached 2200 F and was usually below 2150 F when the temperature in the pit, taken by thermocouple and checked by optical pyrometer, was 2400 F. Orsat readings showed that in most cases only a fraction of the drop could be accounted for by in-leakage of cold air. The sum of this drop plus the drop due to conduction through the walls as calculated from the thermal conductivity of the refractories, still could by no means account for the total measured temperature drop. The cause of the discrepancy is not known but, beyond question, the large temperature drop does occur.

Actually, therefore, in applying any kind of metallic recuperators to soaking pits, assuming proper design, the problem is not that of reducing the temperature of the gases (by air dilution, for example) in order to protect the metal, but rather that of getting the waste gases into the recuperator at a sufficiently high tempera-

ture to heat the air as hot as desired without requiring an unduly large amount of heat-transmitting surface.

T. E. Dixon: We have described certain European recuperators and preheaters, in response to a suggestion made some time ago by Mr. Vierow, and in so doing, we have mentioned developments which have taken place in Europe during the last several years—notably the location of recuperators outside flues and the evolution and application of the radiation recuperator. To do this within reasonable brevity made it necessary that our treatment of radiation heat exchange be somewhat rudimentary.

We appreciate, of course, that re-radiation takes place from the first tube bank in flue-type recuperators to successive tube rows. By reducing the figure for the quantity of heat transferred due to radiation (q_{rad}) to two-thirds of the calculated value, we took account of re-radiation in calculating the tube wall temperature (t_w). Even if we had reduced q_{rad} to 50 per cent of the calculated value, the result would have still given dangerously high tube wall temperatures in the overheated condition. The ratios of 2.5 to 1 and 1.75 to 1, as suggested by Mr. Keller, might equally well be regarded as somewhat oversimplified. They relate, by simple proportion, variants whose relation is by no means linear. The quantity of heat transferred due to radiation, as we have said, is a function of the 4th power of the absolute temperature, whereas heat transferred due to convection in a flue-type recuperator is a function of flue gas velocity to the 0.6 power. Thus the proportions, both chosen and suggested, can only be valid for one given set of circumstances. The figure quoted is based on considerable practical experience with flue-type recuperators at the temperatures selected. In deriving tube wall temperatures in the examples given, the volume of air flowing in the air pass was not reduced. Let us assume that there was sufficient re-radiation to an inner tube to increase the heat transfer on the air side a further 50 per cent, as Mr. Keller suggested. Our figure of 16 would increase to 24 Btu per sq ft hr, F. Substituting this new value in the equation for tube wall temperature, t_w under overheating conditions falls only from 1950 F to 1860 F.

There is little point in prolonging a discussion on the degree of influence of radiation. We prefer to regard the variation in interpretation of effect as an honest difference of opinion between designers. The principal point at issue is that, under certain conditions, the heat transferred due to radiation (q_{rad}) is so much greater than that due to convection (q_c) that q_{rad} has a preponderant influence in solving the equation for h, which is the heat transfer factor of the heating medium. Mr. Keller admits this when he says "Radiation from the brickwork does, beyond question, very considerably increase the heat transfer to the front of the first row of tubes in the flue-type recuperator."

In the passage in Professor Trinks' book to which Mr. Keller refers, we find the statement: "Those (temperatures) chosen show the preponderant influence of radiation over convection."

Furthermore, we believe that the necessity to resort to the use of the hot air bleed and the constant pressure arrangement in the first tube boxes of the flue-type recuperators constitutes practical recognition of our theory. These devices are expensive and the hot air bleed in particular may cause instrumentation complications. Neither device is necessary in the tubular design described in this paper.

Mr. Keller refers to turbulence and eddies at the point where the flue gases enter the tubes. This is a subject over which there has been much controversy in the past, and experts have not always agreed. Very recently, however, this subject was studied by Dr. Grass, of the Mannesmann Research Institute, using information developed by the United States National Advisory Committee for Aeronautics, and the results developed are considered the most reliable now available. A fairly comprehensive treatment of the results is to be found in the fifth edition of Alfred Schack's book, "Der Industrielle Warmeubergang," pages 120 through 130. As may be anticipated, the shape of the tube mouth has considerable bearing on the local heat transfer coefficient, which may be obtained from the following equation:

$$\alpha = \alpha_\infty \left(1 + \frac{cd}{L}\right)$$

where

α = local heat transfer coefficient
α_∞ = heat transfer coefficient at point where flow in tube is stable
c = a constant depending on the shape of the tube mouth
d = diam of tube
L = length of tube

Substituting the appropriate values in this equation, we find that the local heat transfer coefficient near the tube mouth exceeds the ultimate heat transfer coefficient of the entire tube by only 20 per cent. It will be recalled that the tube in the vicinity of the lower opening is specially cooled by the double tube sheet arrangement. On the subject of after-combustion caused by entrance turbulence, it is hard to conceive that it is any greater in the tubular design than in the flue-type unit, where successive tube rows promote the same effect through the entire recuperator.

It is true that the flared tube end at the base of the recuperator is cooled only by conduction. However, this flared section is fabricated from high-alloy heat resisting steel, and the design is such that, even if the flared end should fail, it will not affect the operation of the recuperator and will certainly not cause the tube bundle to need replacement.

We do not know which recuperators Mr. Keller refers to, when he mentions a pressure drop of 2 in. water column on the air pass. Those with which we are familiar frequently use 8 to 10 in. water column pressure drop and more. It may well be that he refers to pressure drop on the waste gas pass, where there is a growing tendency in Europe, in spite of the cost of power, to employ induced draft fans to exhaust waste gases. Pressure drops of 1.5 to 3 in. water column on the waste gas pass are regularly being used in the belief that they improve furnace pressure control and avoid striation under conditions of extreme turn-down. These conditions apply particularly to soaking pits.

Mr. Keller's remarks on pickup indicate that he has

been concerned hitherto with much lower pickup values than are being achieved regularly in Europe. There are literally hundreds of examples of recuperators in operation providing a pickup of 80 per cent.

Several of the participants in the discussion have suggested that the idea of flue-gas-through-the-tubes is not new. We appreciate this, and we are also aware that the idea has been tried on several occasions previously. However, as Professor Trinks has stated, the present design circumvents the failings of earlier types, and it does so by reason of development work over the past decade.

F. D. Hazen: The fire tube type recuperator is not new in the United States. A. M. Byers built their plant at Ambridge during the years 1929 and 1930 and shortly thereafter installed a hot blast recuperator practically identical with the recuperator shown in Figure 3. Byers had so much difficulty keeping this recuperator in operation that they eventually discontinued its use and removed it. Furthermore, another recuperator of this same design was brought out in Pittsburgh as early as 1923, and eventually dropped out.

Apparently the authors have exerted great effort in concocting formulae to show that the flue type recuperator cannot be built to withstand even moderately high flue gas temperatures. We do not know where they picked up these formulae, but there are many installations of flue type recuperators operating with flue gases ranging in temperature from 2000 to 2300 F coming in contact with the recuperator tubes, and service life is excellent. It is most difficult to overcome facts established by actual practice.

R. A. Lambert: Messrs. Dixon and Kuhne have presented an excellent sequel to Emil Vierow's review of metallic recuperators which can be found in the 1954 AISE Proceedings. Mr. Vierow's paper covered the recuperators used in the American steel industry, whereas Mr. Dixon's presentation details design of European recuperators which have now become established to some extent in this country.

There appears to be a difference of opinion as expressed in Mr. Keller's comments and the presented paper relative to interpretation or application of formulae for radiation effects. We who have been exposed to formulae of such nature are fully aware that there is no universally accepted method by which accurately calculated results may be obtained. Both Professor Trinks and Mr. Keller were my instructors in college, and the application of their calculation methods, or any others, with the necessary assumptions based on empirical data, could easily produce calculated variations of 100 degrees, which appears to be the difference in question. The emissivity value and Stefan-Boltzmann constant used for the designed physical location of the tube wall, plus assumptions as to the re-radiated quantity of heat flow from the first row of tubes, is where this difference in calculated tube wall temperature occurs. Obviously experience pretty much dictates use of proper values.

It is correct that this heat transfer is of such complexity that, as Mr. Keller points out, differential calculus is perhaps a better method. However, Messrs. Dixon and Kuhne, for the presentation purpose, seem to have done well. For practical application, it would appear that their calculation of tube wall temperature, since it is higher, would render the greater margin of safety for design calculation.

We definitely agree with all persons involved on one of the primary points the paper emphasizes. The influence of radiation on tube wall temperatures for the first tube rows is far greater than any influences from heat transfer by convection.

The paper mentions dangers of exposing the recuperator metal to high waste gas temperatures in the range of 2150 F under a malpractice that might occur in fuel firing. This is entirely possible. I cannot conceive, however, of the waste gas temperature from a single soaking pit exceeding 2300 F under normal operation. Under these excessive temperature conditions, the paper points out that the "flue type" recuperator, with its tube wall exposed to radiation as well as convection heat transfer, "the tube wall temperature can very easily reach dangerous proportions."

At the Pittsburgh Works, our flue type metallic recuperators are in the waste gas stream following a tile recuperator and, obviously, they are not subject to higher temperature ranges. Our temperatures do not exceed 1600 F. However, we have visited several plants having the flue type recuperator installation on slab heating furnaces where waste gas temperatures doubtless attain maximums in the neighborhood of 2100 F and possibly as high as 2300 F. Our information from these installations verifies Mr. Hazen's comments that even with these high temperatures of waste gases, the service life is excellent.

In an attempt to clarify some of the comments, I am sure that no comparison should be made from a structural design standpoint with the recuperators presented in Messrs. Dixon and Kuhne's paper as being in any way a duplication or unmodified carry-over of the design features mentioned in both Mr. Keller's and Mr. Hazen's comments relative to those recuperators of 35 years ago or more. Certainly, the European designs have overcome, as Professor Trinks points out, the objectionable features that were existent many years ago, as has also been the case in this country. We should keep in mind that in European operated recuperators, fuel savings far outweigh consideration given to maintenance and labor expense. On the North American continent, labor costs and material costs usually receive primary consideration in the installation of any heat-saving devices and fuel savings are more difficult to justify. As expressed by the authors and commentators, be the recuperator design of the flue type or fire tube type, the end results of net dollars to be saved is the answer to the selection for any specific application. This includes consideration of investment costs, including taxation and borrowing costs, maintenance and routine labor expenses.

Messrs. Dixon and Kuhne are to be congratulated for bringing the story of recuperator application in Europe and for their information to the American steel industry as to the designs that have become established in this country as well as those designs which are available to us. The frank expression of ideas by them and by the other participants in discussion gives valuable service to the AISE and the steel industry ▲

by I. E. MADSEN

Developments in the Iron and Steel Industry during 1957

GENERAL

ALTHOUGH 1957 did not set any new records for steel production, it was nevertheless one of the best years in the history of the industry, both from the standpoint of production and profitable operations. The year did set a new record for blast furnace production. The sharp dropoff in production at the end of the year tended to give the current outlook a pessimistic tinge.

Operations in 1958 are expected to continue for some time into the new year at about the same tonnage rate as in the last quarter. The operating rate in per cent will of course be appreciably lower because of the new higher capacity on which production may be based.

The amount of steel which is added or taken from inventories will be an important factor in actual operations as it was in the last quarter of 1957. Realizing that steel capacity has caught up to normal require-

ments, steel buyers see no need to maintain large inventories, so 1957 can be said to be the year when steel capacity caught up with demand.

A number of other items stood out during the year. Not for many years have there been so many mergers. Although the federal government is still blocking the merger of Youngstown Sheet and Tube Co. and Bethlehem Steel Co., some five or six other companies combined in one way or another.

There was great emphasis on the application of automatic controls, particularly on rolling mills. Oxygen steelmaking made great forward strides, and although not spectacular, advances in blast furnace operating techniques, along with high scrap prices, enabled the industry to set an iron production record.

Total production of steel in 1957 was 112,707,711 tons or 84.5 per cent of the 1957 capacity. Of this open hearth production totaled about 101,657,514 net tons or 87.0 per cent of capacity, electric furnace production totaled 8,575,396 tons or 71.2 per cent of capacity, and bessemer production totaled 2,474,801 tons or 54.9 per cent of capacity.

These figures compare with a total of 115,216,149 net tons in 1956, consisting of 102,840,585 tons from open hearths, 9,147,567 tons from electric furnaces and 3,227,997 tons from bessemers.

Blast furnace production in 1957 was a record 79,000,000 tons including ferromanganese or 91 per cent of the 1957 capacity of 86,817,950 tons. This compares with 75,959,560 tons in 1956. Coke production totaled about 74,000,000 tons.

Shipments of finished steel in 1957 totaled about 81,000,000 net tons, about 4 per cent under 1956. Shipments of stainless and heat resisting steels were 620,000 tons, down 10 per cent from 1956, and shipments of silicon electrical sheets and strip were 625,000 tons in 1957, down 23 per cent. Tool steel shipments were down 22 per cent to 100,000 tons in 1957.

On the other hand, shipments of certain products showed increases. Among these are heavy structural shapes, sheet piling, line pipe, oil country goods and electrolytic tin plate.

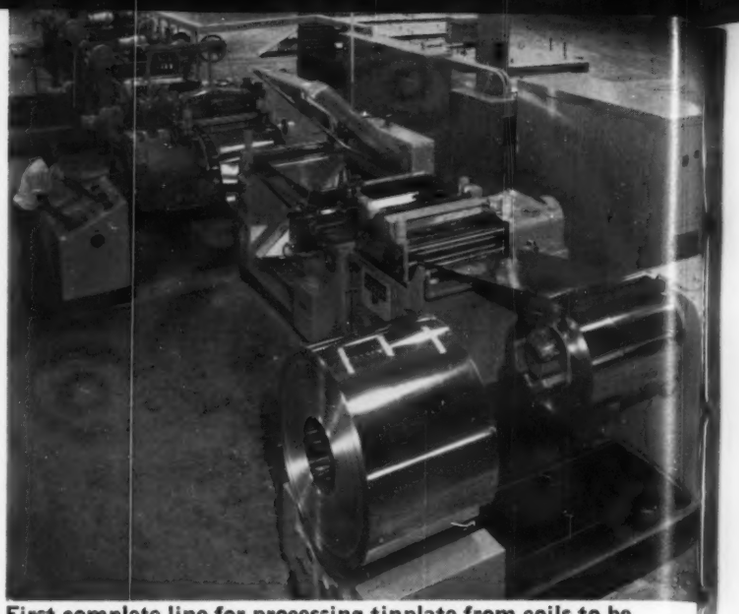
In 1957 the steel industry added some 8,000,000 tons of steelmaking capacity.

Plans for expansion programs have involved constant efforts by management to gain maximum additional capacity and improved operation with a minimum investment. Such expansions have been largely based on modernization and supplementation of existing facilities.

Some new types of low cost steelmaking equipment are being built, but in general expansion is conventional. U. S. Steel's increase is typical of the pattern. Of the approximately 2,000,000 tons to be added in the Chicago and Pittsburgh districts, only one new facility is included, an electric furnace at the Duquesne Works. Most plans are concentrated on getting more out of existing units.

The 1957 expansion was accomplished despite the fact that, before the year started, the government turned the industry down on accelerated amortization of proposed new facilities.

Additional expansion by the steel industry requires the solution of the difficult problem of obtaining capital. Unfortunately, the logical solutions to the capital problem are not in the hands of the steelmaker. New capital from investors can be obtained only when the steel industry is an attractive investment. At present, little such capital can be obtained. Capital obtained from retained earnings will not meet the need. In the long run, it will be necessary for some sort of tax change, perhaps through accelerated amortization or through some formula by which depreciation can be taken on the replacement cost of facilities rather than on the original cost.



First complete line for processing tinplate from coils to be operated by the canmaking industry started on May 9, 1957.

From all appearances at the end of the year, capital spending in all industries for 1958 will drop by almost $3,000,000,000 under the $39,000,000,000 reached in 1957. The steel industry is dropping about 24 per cent according to government figures issued in November. Estimated capital spending by the iron and steel industry for 1957 totaled $1,857,000,000 and spending plans for 1958 total $1,411,000,000. This compares with $1,336,000,000 in 1956.

The growth in the steel industry has not been confined to any one locality. All districts have increased in productive capacity, and all states in which steel is made have increased their capacity since the war with the exception of New Jersey and Tennessee. It is believed, however, that the seven far western states will grow in capacity faster than the rest of the country, for it has been estimated that they will need some 10,000,000 tons of steel by 1965. Expansion programs under way in that area indicate that steel requirements at that time will be largely met by local sources.

The steel industry moved west again during the year. The new center of steelmaking capacity is at Westminster, Ohio. Center of blast furnace capacity is at LaRue, Ohio; and Shelby, Ohio, is the heart of hot rolled sheet and strip capacity. All of these places are located within a 35-mile radius in northwestern Ohio.

In addition to an increase in capacity, most of the areas and states have increased the variety of products which they may produce. The largest capacity gain in any product is probably hot rolled sheets where between 1954 and 1957, capacity increased 2,000,000 tons to about 33,500,000 tons. Merchant bar capacity had a loss of about 150,000 tons to 14,000,000 tons.

A large increase is in coils for cold-reduced black and tin plate which increased 2,500,000 tons to 9,285,000 tons. Plate has increased 580,000 tons to 9,227,000 tons. Heavy structural shapes have increased some 2,000,000 tons to 7,600,000 tons. Wire rod has gone up 373,000 tons to 7,375,000 tons. Skelp has increased 100,000 tons to 5,700,000 tons. Blanks, rounds and billets for seamless tubes have gone up 480,000 tons to 5,400,000 tons. Cold finished bar capacity went up 250,000 tons to 4,000,000 tons. Cold-rolled sheets went up 2,300,000 tons to 19,300,000 tons; galvanized sheets went up 450,000 tons to 3,800,000 tons; electrolytic tin plate increased 1,000,000 tons to 5,500,000 tons; cold-rolled strip lost 350,000 tons to 2,950,000 tons; and wire capacity went up 450,000 tons to 7,250,000 tons.

The decrease in demand for rail has been reflected in Inland Steel's decision to go out of the rail business and to modify their mills to produce heavy structural sections. In Chicago, U. S. Steel also will start operation of a new structural mill in 1958. Lukens Steel is increasing plate rolling capacity, and Barium Steel is increasing the power on its 126-in. plate mill in Harrisburg.

Increase in tinplate production included a new electrolytic tinning line at U. S. Steel's Gary plant. Another is scheduled for completion in 1958 at Columbia-Geneva. Bethlehem Steel finished an electrolytic line in February, and another late in the year. Youngstown Sheet & Tube Co. put in a new line at Indiana Harbor. Kaiser Steel Corp. has a line under construction to be ready in early 1959. These programs should add some 1,000,000 tons of electrolytic capacity.

Another trend in the tinplate industry is the growing use of tinplate in coils. In March Jones & Laughlin made shipments of coiled tinplate to the American Can Co.'s new plant at Tampa where a modern can-making unit handles plate at several hundred feet per minute. It is planned to boost this speed to 600 fpm. Other companies who are now shipping coils include U. S. Steel's Columbia-Geneva Div. and Gary plant, Tennessee Coal & Iron Div., Bethlehem Steel, etc.

An interesting development during the year which may affect tinplate was the signing of a contract by a large oil company for up to 60,000,000 quart-sized motor oil cans to be made of aluminum. It is claimed that the system which has been developed for reclaiming the cans after use will reduce the cost differential between aluminum and the conventional tinplate. Rough computations indicate, however, that the material cost alone of the aluminum can be as much as the finished can made out of tinplate. These figures were disputed by spokesmen from the aluminum industry.

Kaiser Aluminum also put into production a special aluminum can with a seamless body and bottom in one piece. The manufacturing process is a deep draw which forms the sides and bottom. The top is also shaped in the form of a can and the two parts are put together in a snug-friction fit which is reported to be waterproof and airtight.

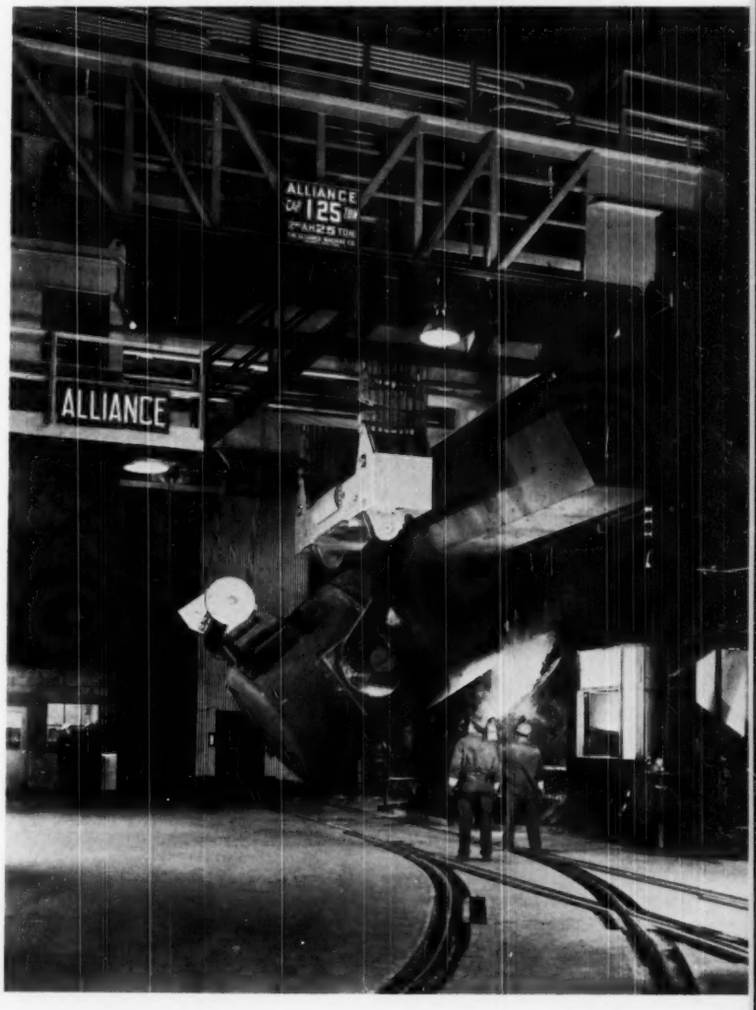
Some important expansion programs are in the stainless field. Allegheny Ludlum made progress with a new family of chromium-nickel-manganese stainless steels which need only half as much nickel as traditional grades. Armco has a new precipitation hardening stainless steel which, because of its high heat and strength properties, promises to be used extensively in aircraft and missiles. Rolling facilities at the company's Butler plant have been expanded. Crucible Steel Co. has a $20,000,000 expansion program to boost finished stainless sheet and strip some 70 per cent. Jones & Laughlin has entered the stainless market through their purchase of Rotary Electric Steel, and their two new electric furnaces in the Cleveland district could also be used for this product.

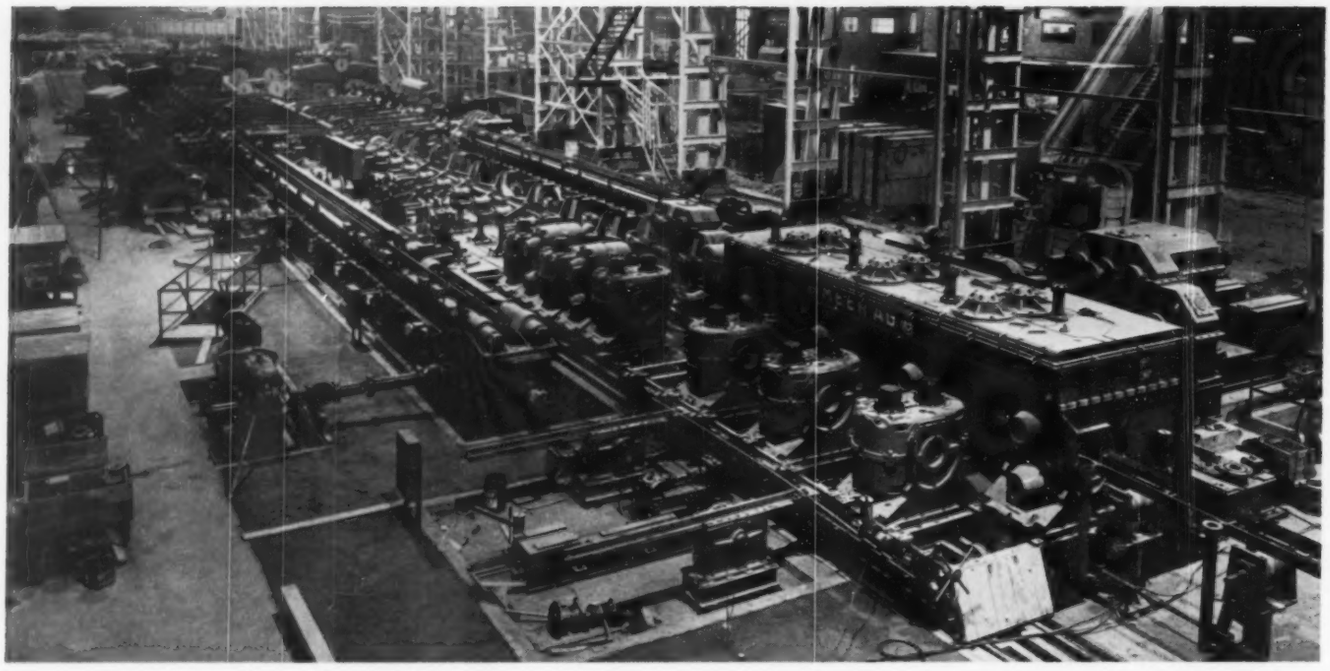
Increases in capacity changed the ranking of the first ten companies somewhat. U. S. Steel, Bethlehem, Republic and Jones & Laughlin run one, two, three, four, as in the previous year. Youngstown Sheet & Tube, however, took fifth place from National Steel which became No. 6. Armco Steel moved into the seventh spot, taking that place away from Inland Steel which became No. 8.

The steel industry was badgered by investigations during the year. One specifically aimed at the industry was the investigation by Senator Estes Kefauver on the so-called administered price industries. Steel industry spokesmen fought back with statistics and figures which took much of the steam out of the investigation.

In testimony before the investigation committee, spokesmen from U. S. Steel reported that the steel

Oxygen steelmaking received a tremendous boost as J&L's new plant went into operation at the Aliquippa works.





A new automatic seamless tube mill, the first one in Canada, went into operation at a new plant at Sault Ste. Marie of the Mannesmann Tube Co.

industry between 1946 and 1956 spent some $8,395,-500,000 to add 41,000,000 tons to its capacity. Of this, some $4,628,700,000 was furnished by depreciation accounts and some $3,766,800,000 met by new money. Of the latter, $2,441,600,000 was obtained by borrowing, $462,000,000 came from stock and $1,408,500,000 came by reinvestment, including $545,000,000 for refinancing.

All of the steel producers have found that the operating break-even point is materially lower than had previously been estimated. Jones & Laughlin Steel Corp. reported that their break-even point will be about 45 per cent of capacity when present expansion is completed. New, more modern facilities are reducing this figure in all companies.

Operations research was found to be a new and effective tool to help management make sound decisions. As a result of such research, it is possible to minimize over-all costs and provide accurate over-all plant data.

Some of the applications where statistical analysis has been found useful are on such items as:

1. Determination of inventory levels.
2. Establishing feasibility of warehousing certain types of products.
3. Auditing of time standards in connection with incentive plans.
4. Scheduling of planned equipment shutdowns.
5. Evaluation of alternate purchasing policies.

On July 1, the steel industry increased wages and benefits in accordance with the three-year labor contract signed in the middle of 1956. These changes raised employment costs about 6 per cent. In turn, prices of carbon and alloy steels were raised an average 4 per cent or about $6 a ton.

The increases include a 7¢ per hour raise for all employees, plus a 0.2¢ raise in the present differential of 6.3¢ per hour between each of the 32 job classifications. In addition, there was a cost-of-living increase of 4¢ per hour. Nonovertime work performed on Sunday went up to one and one-fifth times the regular rate. Pay for certain of seven specified holidays was increased to double-time and one-tenth. Many of the steel producers felt that the price increase was inadequate since it did not cover the increases in cost.

It was estimated that the total payroll in the iron and steel industry in 1957 was probably over $4,000,000,000 for the first time. This compares with some $3,800,-000,000 paid out in 1956. The average hourly earnings for steel workers during the year was over $2.90 or 20¢ more than 1956. In addition to this, there is some 29¢ per hour paid for supplementary benefits.

The year was an important one from the standpoint of mergers and acquisitions. Jones & Laughlin Steel Corp. was involved in several. In one transaction, they purchased properties of the Louis Berkman Company at Louisville, Ohio. This property will be used by J&L for installation of flat rolling equipment for its stainless steel division. Completion of the program is scheduled for the third quarter of 1958.

J&L also acquired the Cold Metal Products Co. This property will be known as the strip steel division. Cold Metal's Youngstown plants have facilities for producing cold rolled strip in low carbon, high carbon, alloy and stainless grades. Their Indianapolis plant produces cold rolled strip in low carbon, high carbon and alloy grades.

Another J&L acquisition was Rotary Electric Steel Corp. which became the company's stainless steel division. This division has a six-furnace electric melt shop, a 36-in. blooming mill with nine soaking pits, a 4-stand, 2-high continuous billet mill, an 11-stand continuous bar and rod mill, a new bar and rod rolling mill (15-stand) and other facilities.

In July Jones & Laughlin completed negotiations for the acquisition of approximately 2700 acres of land in Chambers County, Texas. The land fronts on Galveston Bay and Ceday Bayou, from which there is

ready access to the Houston ship channel. The site is ideal for the construction of a steel plant.

Interlake Iron Corp. was merged during the year with Globe Metallurgical Corp. Globe Metallurgical is located near Beverly, Ohio, and produces ferroalloys used primarily in the manufacture of stainless and alloy steels.

Copperweld Steel Co. merged with Superior Steel Corp., which became the Superior Steel Div., of the Copperweld Steel Co. This merger, handled through an exchange of stock, adds hot and cold rolled steel strip to the products of Copperweld and permits them to participate in the growing stainless steel market. For Superior it assures a supply of semi-finished steel.

Jessop Steel purchased Green River Steel Corp. during the year. Green River Steel will retain its identity but will be a wholly-owned Jessop subsidiary.

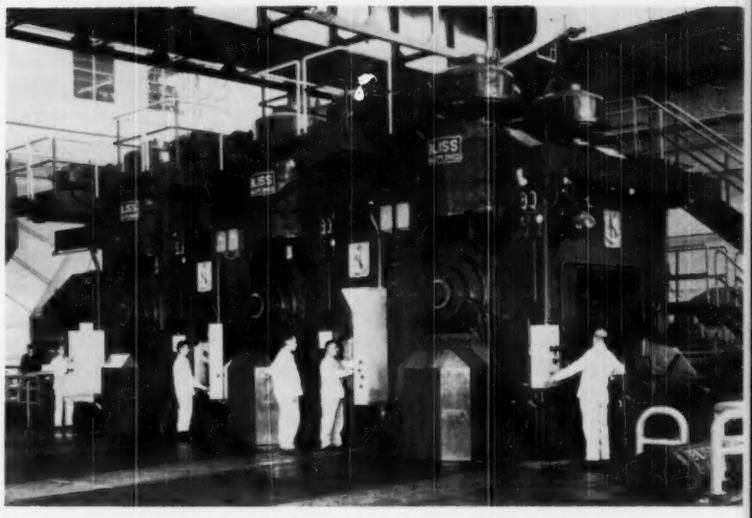
The bankrupt Northeastern Steel Corp. was sold to Carpenter Steel Co. of Reading. The sale was complicated by suits from minority committees but was eventually approved by the courts. Carpenter Steel announced that after the approval of the negotiations it would invest up to $6,500,000 in the newly acquired subsidiary, which is to be called Carpenter Steel of New England, Inc. Much of the expenditure will be for additional machinery and in-process inspection equipment.

Another merger under discussion is one in which the Universal Cyclops Steel Corp. plans to acquire Reeves and Empire Steel Co. In the merger, which has been approved by the board of directors but still requires stockholder approval, the Empire-Reeves Steel Corp., would be formed as a wholly-owned subsidiary of Universal-Cyclops to operate the Mansfield and Dover plants. Empire is a basic producer of hot and cold rolled carbon and silicon strip and sheet and other sheet and plate products. It has an annual open hearth capacity of 500,000 ingot tons, and has been a principal supplier of semi-finished steel for Reeves Steel & Mfg. Co. which makes galvanized sheets, roofing and other metal products. Excess blooming and hot strip rolling capacity at the Empire plant will be made available to Universal for its expanded stainless steel program.

Late in the year, the board of directors of Armco Steel Corp. and National Supply Co. agreed to a merger through an exchange of stock. Stockholders approval will still be required. This merger adds pipe and oil country goods to Armco's products, and provides National Supply Co. with a source of semi-finished steel.

No decision was reached on the possible merger between Bethlehem Steel Corp. and Youngstown Sheet & Tube Co. A number of briefs were filed with the courts and several hearings took place. Bethlehem and Youngstown contend that they do not compete significantly with each other, and that the combined company can give better competition within the industry. The Justice Dept. claims that the two companies do compete. The companies would like to get a court trial definitely scheduled as soon as possible. Legal maneuvers will undoubtedly be spread out over a long period of time before a decision is reached. The anti-trust division wants the court to bar the merger without a trial.

Bethlehem Steel Corp. has major expansion plans for Youngstown Sheet & Tube Co. if the courts allow the two companies to merge. This would involve a $358,000,000 program to increase capacity at Youngstown's plants by 2,600,000 tons. Of this, $268,000,000 would be spent at the East Chicago plant to expand finishing capacity for sheared plates, structurals, hot-rolled bars and rolled steel wheels. The remainder would be used at Youngstown for hot and cold-rolled sheets. The proposed expansion would give the Bethlehem-Youngstown combine a capacity of 29,300,000 tons.



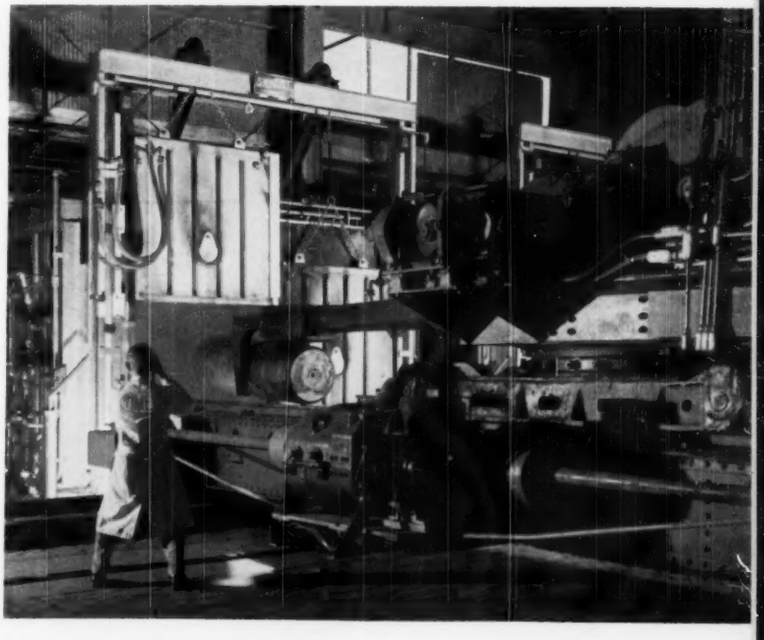
This three-stand, four-high cold rolling mill is the first multiple stand tandem mill to be erected in any of the Benelux countries.

Bethlehem Steel Co. was also reported to have acquired about 3500 acres of land on Lake Michigan about eight miles east of Gary, Ind.

It was also announced that National Steel has three sites for possible expansion, one at Camden, N. J., one in the Chicago district, and a new one at Weirton, W. Va.

It is reported that a new steel plant is planned for

Titanium Metals Corp. of America put into operation a new plant at Toronto, Ohio. First ingot is shown being removed from the furnace prior to forging.



Tampa, Fla., to be called the Florida Steel Corp. This company plans an electric arc furnace and a rolling mill, with a capacity of up to 30,000 tons a year. The major product would be reinforcing bars. Estimated cost is about $1,250,000 and completion is scheduled for summer 1958.

It was also reported that a new steel company known as the St. Lawrence Steel Corp. will start production of heavy and medium steel plate at Gary, Ind., in 1958. Incorporated in June, 1957, the company plans a capacity of about 600,000 tons per year of finished products. The plant was built by the government during World War II, and since has been shut down. It was sold to the American Auto Parts in 1956.

DETAILED EXPANSION

The enormous steel plant expansion program which has continued essentially unabated since the end of World War II and particularly since the Korean War is finally coming to a close, although some units must yet be completed and many units still need finishing touches. However, the cutback in demand has tabled for the present many of the plans which were being prepared to meet the very high steel demands forecast for the next 10 to 15 years.

The attached table on expansion is an attempt to outline the status of some of the major programs. Unfortunately such a table is out of date as soon as it is prepared.

The information on this table has been obtained from company reports, official company releases, financial statements, discussions, etc. Only the major items are listed. Items listed are those either under construction or on the construction schedule for 1957. Items with a (c) after them were completed in 1957. Some other items without a (c) after them were undoubtedly also completed in 1957 since there is usually more pressure to release information on new projects than there is on completions. Some items are omitted because the information is not available.

When possible, items and costs are allocated against a plant location. Sometimes they are given as over-all generalized figures and cannot be allocated against a particular plant. Where figures are given in parentheses, they are breakdowns indicating the portion for the plant on the same line as the figure. Such figures are included in the over-all figures without parentheses given for that particular company or plant.

In most cases the figures included are only those which have been officially authorized. The partial totals of $2,445,080,000 and 15,574,460 tons of capacity are not complete figures since, in a number of cases, no cost or tonnage estimates have been released on some of the work under way. True totals are appreciably higher.

Nor can the cost and tonnages for this year be added to last year's report, since projects which may be carried over from one year to another before completion are listed in both years. One exception to this is the listing for Armco Steel which covers only those items announced in 1957.

PARTIAL LISTING OF ANNOUNCED EXPANSION PLANS—1957

(c) Denotes completion in 1957

Company and plant	*Cost*	*Additional ingot capacity, tons*	*Steelmaking facilities*	*Additional iron capacity*	*Ore preparation*	*Hot mills*	*Cold mills*	*Finishing facilities*	*Heating furnaces & pits*	*Miscellaneous*
Acme Steel Co. Calumet Harbor, Ill.	$23,000,000	450,000	Two 50-ton oxygen converters	Two 25-ton hot blast cupolas	.....	Blooming and billet mill	.....	.....	Three batteries 4-hole soaking pits	Oxygen plant
Alan Wood Steel Co. Conshohocken, Pa.	$4,145,000	.....	One open hearth charging crane (c)	Enlarge blast furnace (c)	New 15-ton ore bridge (c)	.....	4-High temper mill (c)	.....	.....	Improvements in by-product plant (sulphate and light oil scrubbers) (c). Main office building enlarged (c). Employment building enlarged (c). Paving railroad bridge for truck handling (c). Additional coke screening facilities (c). Additional fire protection equipment (c)
Allegheny Ludlum Steel Corp. Brackenridge, Pa.	.....	.....	.....	.....	.....	.....	1 Sendzimir mill (c)	.....	8 Soaking pits (c). Anneal and pickle line (c)	Motorized slab grinding line (c)
Dunkirk, N. Y.	.....	.....	.....	.....	.....	.....	.....	.....	.....	2,000-Ton forging press (c)
West Leechburg, Pa.	.....	.....	.....	.....	.....	.....	.....	.....	Anneal and pickle line(c)	.....
Watervliet, N. Y.	.....	.....	28-In. consumable electrode furnace (c)	.....	.....	.....	.....	.....	.....	.....
Armco Steel Corp. (1957 announcements only) Ashland, Ky.	$50,000,000	750,000	Melting unit	One 1400-Ton blast furnace	.....	.....	.....	.....	.....	.....
Houston, Texas	$1,000,000	.....	.....	.....	.....	.....	.....	.....	.....	River terminal
Kansas City, Mo.	$10,000,000	.....	.....	.....	.....	Rod mill	.....	.....	New heating furnace	.....
Middletown, Ohio	$1,500,000	.....	.....	.....	.....	.....	.....	.....	.....	Spiral weld pipe plant

Company and plant	Cost	Additional ingot capacity, tons	Steelmaking facilities	Additional iron capacity	Ore preparation	Hot mills	Cold mills	Finishing facilities	Heating furnaces & pits	Miscellaneous
Zanesville, Ohio	$500,000	.....	.....	.....	.....	.....	.....	.....	.....	Processing facilities
Armco Drainage & Metal Products, Inc.	$825,000	.....	.....	.....	.....	.....	.....	.....	.....	Expansion of three fabricating plants
Babcock & Wilcox Co. Koppel, Pa.	$13,000,000	.....	Electric furnace	.....	.....	.....	.....	.....	.....	.....
Barium Steel Corp.										
Burlington Co., N. J. (Planning stage only)	$50,000,000	800,000	Oxygen converters	1700-Ton daily blast furnace	.....	.....	.....	.....	.....	.....
Phoenixville, Pa.	$500,000	.....	.....	.....	.....	.....	.....	.....	.....	Oxygen plant
Harrisburg, Pa.	.....	.....	.....	.....	.....	Convert plate raill from steam to electricity	.....	.....	.....	.....
Bethlehem Steel Corp.	$200,000,000	2,500,000								
Bethlehem, Pa.	.....	.....	.....	.....	.....	.....	.....	.....	2 Blocks soaking pits	.....
Johnstown, Pa.	.....	.....	.....	Enlarge two blast furnaces	15-Ton ore bridge	.....	.....	.....	.....	.....
Lackawanna, N. Y.	.....	(600,000)	250-Ton open hearth (c)	2 Blast furnaces modernized	.....	.....	Skin pass mill (c)	.....	5 Annealing furnaces (c)	.....
Sparrows Point, Md.	.....	.....	Seven 350-ton open hearths	One new blast furnace. Enlarge blast furnace	Two sintering lines	45x90-In. slabbing mill (c). 4-High, 160-in. plate mill. Electric weld pipe mill	5-Stand, 48-in. cold mill. Two 4-high skin pass mills	Two Electrolytic tin plate lines (c)	Eight blocks Soaking pits. Continuous annealing line (c). Rebuild four slab furnaces	Coke oven battery
Steelton, Pa.	.....	.....	.....	.....	.....	20-In. bar mill improved	.....	.....	Heating furnace	.....
Bethlehem Pacific Coast Steel Corp. Seattle, Wash.	.....	420,000 (175,000) (net gain)	Two 100-ton electric furnaces, replacing 5 open hearths	.....	.....	23-In. bloomer. Bar mill. Add plate mill stand	.....	.....	Soaking pits	.....
Borg Warner Corp. Chicago Heights, Ill., Calumet Steel Div.	.....	.....	Electric furnaces	.....	.....	14-In. mill improvements. Tube mill improvements	.....	.....	Combination rail and billet furnace	Roll shop
Calstrip Steel Corp. Los Angeles, Calif.	.....	.....	.....	.....	.....	.....	.....	.....	Two annealing units. Six annealing bases	.....
Colorado Fuel & Iron Corp.	$20,000,000									
Pueblo, Colo.		116,000(c)	Enlarge open hearth (c).	.....	.....	.....	.....	.....	.....	.....
		200,000(c)	One 200-ton open hearth (c)	.....	.....	Stretch mills(c)	.....	.....	Two soaking pits (c)	.....
John A. Roebling's Sons plant Trenton, N. J.	$2,500,000	.....	.....	.....	.....	.....	.....	.....	.....	Electric wire cable facilities
Copperweld Steel Co. Warren, Ohio	$10,100,000	.....	.....	.....	.....	35-In. bloomer (c)	.....	.....	Two soaking pits (c)	Continuous annealing furnace (c)
Crucible Steel Co. of America										
Midland Works Midland, Pa.	$20,000,000	.....	.....	.....	.....	44-In. high lift bloomer	.....	.....	Hot strip continuous heating furnace. Two 3-hole soaking pits	.....
Sanderson Halcomb Works, Syracuse, N. Y. / Vacuum Metals Div. Syracuse, N. Y.	$1,500,000	960	One 3,000-lb vacuum induction furnace	.....	.....	.....	.....	.....	.....	Applied research laboratory Melt shop building
Detroit Steel Corp. Portsmouth, Ohio	$19,000,000	210,000	One 275-ton open hearth (c)	.....	.....	Add 2 stands to hot strip (c)	.....	Sheet and strip finishing	Four soaking pits. One flame scarfer. Six coil annealing furnaces (c)	One 156-in. welded wire fabric machine
Eastern Stainless Steel Corp. Baltimore, Md.	$8,000,000	44,000(c)	30-Ton electric furnace (c)	.....	.....	.....	One 50-in. Sendzimir (c). One cold (c)	Five lines (c)	Two (c). One (c)	.....
Empire Steel Corp. Mansfield, Ohio	.....	.....	.....	.....	.....	.....	.....	.....	Continuous annealing line (c)	.....
Granite City Steel Co. Granite City, Ill.	$18,500,000	384,000	Open hearth improvements	.....	Sintering plant	.....	Cold strip improvements	.....	Soaking pits	Oxygen plant

PARTIAL LISTINGS OF ANNOUNCED EXPANSION PLANS—1957

(CONTINUED)

Company and plant	*Cost*	*Additional ingot capacity, tons*	*Steelmaking facilities*	*Additional iron capacity*	*Ore preparation*	*Hot mills*	*Cold mills*	*Finishing facilities*	*Heating furnaces & pits*	*Miscellaneous*
Inland Steel Co.	$280,000,000	800,000(c)								
Indiana Harbor, Ind.	.....	.....	Three 315-ton open hearths (c). Six open hearths to be improved	.....	4000-Ton daily sintering plant. Ore bridge. Ore bridge (c)	Slabbing mill. Wide flange structural mill improved	Cold rolled sheet dept.	.....	Slab furnace	Office building. Two 87-oven coke batteries
Interlake Iron Corp.	.....	.....	.....	.....	.....	.....	.....	.....	.....	One 50-oven coke battery (c). Coke handling system
Chicago, Ill.										
Jones & Laughlin Steel Corp.	$280,000,000									
Aliquippa Works Div.	.....	120,000 280,000(c)	Two oxygen converters (c)	Enlarge blast furnace (c)	.....	One continuous weld pipe mill (c). Electricweld pipe mill (c). 44-In. hot strip mill (c). One continuous weld pipe mill	.....	Seamless (c)	12 Soaking pits (c). 6 Soaking pits	Two hot scarfers (c). Oxygen plant (c). BTX Purification plant (c)
Cleveland Works Div.	.....	100,000 420,000(c)	Open hearth improvements (c). Two 125-ton electric furnaces (c)	2500-Ton sinter line (c)	.....	One bloomer (c). One reversing rougher for hot strip mill	One 56-in. temper mill (c). One-4 stand tandem mill (c)	One 56-in. pickler (c). Two shear lines (c). One shear line	Fifteen 4-stack annealers (c). Six soaking pits (c). Hot scarfer	Oxygen plant
Pittsburgh Works Div.	.....	60,000	.....	Enlarge blast furnace to 1300 tons	.....	.....	.....	.....	.....	.....
Stainless Steel Div.										
Detroit, Mich.	.....	.....	.....	.....	.....	.....	.....	Bar and coil pickling (c)	Annealing (c)	Wire drawing
Louisville, Ohio	.....	.....	.....	.....	.....	.....	Sendzimir. 54-In. temper mill	Continuous annealing line. Continuous pickling line	.....	Five shearing lines
Willimantic,	$16,300,000	.....	.....	.....	.....	.....	.....	.....	.....	Cold draw (c)
Kaiser Steel Corp.	$194,000,000	1,440,000								
Fontana, Calif.			Three oxygen converters	Fourth blast furnace	Sinter plant	New independent hot strip mill. 40 x 90-In. slabbing mill. Conversion of 110-in. plate mill to 148-in.	One temper mill	Second electrolytic tinning line. 60-In. strip pickler	Enlarging 22 70-ton soaking pits. Ten 120-ton soaking pits. One continuous annealing line	90 Coke ovens
Napa, Calif.	($2,000,000)	.....	.....	.....	.....	.....	.....	Expansion of large pipe facilities	.....	.....
Keystone Steel & Wire Co.										
Peoria, Ill.	$10,000,000	.....	Improve OH (c). New OH	.....	.....	Rod and bar (c). Revamp bloomer	.....	.....	Soaking pits (c). Billet (c)	.....
Laclede Steel Co.						Continuous weld mill				
Alton, Ill.										
Lone Star Steel Co.	$8,000,000	150,000	One open hearth	.....	.....	Rod mill. Stretch reducing mill	.....	.....	.....	.....
Lukens Steel Co.	$34,000,000	175,000								
Coatesville, Pa.			One 100-ton electric	.....	.....	4-High plate breakdown mill	.....	.....	Three 3-hole soaking pits	Testing laboratory
McLouth Steel Corp.	$37,150,000									
Trenton plant	.....	238,000	Oxygen converters	Blast furnace	2000-Ton daily sintering plant	.....	.....	.....	Reheat furnaces (c). Soaking pits (c)	Enlarge power plant. Gas cleaning system
Detroit plant	.....	.....	.....	.....	.....	.....	.....	One CAP line	.....	.....
Merritt-Chapman & Scott Corp.	$615,000	20,000								
Milton Steel Div.	.....	.....	One electric furnace (c)	.....	.....	Bar mill equipment (c)	.....	.....	.....	.....
National Steel Corp.	$95,000,000	800,000(c)								
Great Lakes Steel Corp.										
Ecorse, Mich.	.....	.....	.....	.....	Ore yard facilities (c). One 12-ft sinter line	.....	.....	Continuous pickling and cleaning line (c)	Three slab heating furnaces (c). Soaking pits (c)	One 78-oven coke battery (c)
Weirton Steel Co.	.....	.....	.....	.....	One 12-ft sinter line	.....	.....	One 48-in. continuous galvanizing line (c). One 42-in. continuous galvanizing line	One continuous annealing and cleaning line (c)	Coal loader
Weirton, W. Va.										
Northwestern Steel & Wire Co.	.....	.....	.....	.....	.....	16-In. structural and plate mill (c)	.....	.....	.....	.....
Pacific States Steel Corp.										
Niles, Calif.	.....	.....	.....	One 12-ft blast furnace	.....	.....	.....	.....	.....	.....

Company and plant	Cost	Additional ingot capacity, tons	Steelmaking facilities	Additional iron capacity	Ore preparation	Hot mills	Cold mills	Finishing facilities	Heating furnaces & pits	Miscellaneous
Pittsburgh Coke & Chemical Co. Neville Island, Pa.	.....	.....	.....	Improve blast furnace	.....	.....	.....	.....	.....	.....
Pittsburgh Steel Co. Monessen, Pa.	$21,000,000	180,000	Improve open hearths	Modernize blast furnace	.....	30-In. billet mill. Revamp 18-in. rolling mill (c)	.....	.....	.....	.....
Thomas Strip Div.	.....	.....	.....	.....	.....	.....	.....	.....	.....	Miscellaneons specialty equipment
H. K. Porter Co., Inc. Connors Steel Div. Huntington, W. Va.	$2,000,000	.....	.....	.....	.....	Three hot mill stands. Hot mill beds	.....	.....	Reheat furnace	.....
Republic Steel Corp. Buffalo, N. Y.	$166,000,000	1,980,000	.....	.....	.....	.....	.....	.....	.....	Rebuild bar mill furnace (c)
Canton-Massillon, Ohio	.....	(372,000)	Replace three 70-ton electric with three 130-ton electric (c)	.....	.....	32-In. mill (c). 11-In. bar mill (c)	.....	.....	.....	Wire mill expansion (c)
Chicago, Ill.	.....	(305,000)	.....	.....	.....	.....	.....	.....	.....	.....
Cleveland	.....	(500,000)	Two 375-ton open hearths (c)	.....	.....	One 45-in. slabbing mill (c). Additions to hot strip mill (c)	80-In. temper mill (c)	.....	16 Soaking pits (c). Annealing furnaces (c). Slab furnaces	One 51-oven coke battery (c). Boiler shop. Two coke batteries
Gadsden, Ala.	.....	(408,000)	Two 24-ft electric furnaces (c)	.....	.....	54-In. hot strip mill (c)	54-In. 3-stand tandem mill (c)	Continuous pickle line (c)	Two slab heating furnaces (c). Two blocks soaking pits (c). 48-In. continuous galvanizing line (c). Annealing furnaces (c)	.....
Warren, Ohio	.....	(408,000)	Two 24-ft electric furnaces (c)	.....	.....	.....	42-In. 3-stand cold mill (c)	Continuous pickling line (c)	Six continuous annealing lines (c)	.....
Sharon Steel Corp. Sharon, Pa.	$14,000,000	.....	.....	.....	.....	44-In. bloomer & slabber (c)	.....	.....	.....	.....
Farrell, Pa.	$6,450,000	72,000	One 100-ton electric furnace	.....	.....	.....	.....	.....	.....	.....
The Timken Roller Bearing Co. Canton, Ohio	$600,000	2,500	Consumable electrode vacuum furnace	.....	.....	.....	.....	.....	.....	.....
U. S. Pipe & Foundry Co. Birmingham, Ala.	.....	.....	.....	One 1000-ton per day blast furnace	.....	.....	.....	.....	.....	.....
U. S. Steel Corp. Clairton Works Clairton, Pa.	$700,000,000	2,000,000	.....	.....	.....	40-In. bloomer electrification	.....	.....	Two banks soaking pits	Three 64-oven coke batteries (c)
Duquesne Works Duquesne, Pa.	.....	(90,000)	.....	.....	.....	46-In. 2-high reversing slabbing, blooming mill. 36-In. blooming mill. 4-Stand, 21-in. billet mill	.....	.....	Seven banks soaking pits	Metallurgical laboratory
Edgar Thomson Works Braddock, Pa.	.....	(120,000)	Open hearth improvements	.....	.....	.....	.....	.....	.....	.....
Fairless Works Fairless Hills, Pa.	.....	.....	.....	28-Ft blast furnace (c)	One 4000-ton sintering line (c). Ore bridge (c).	.....	.....	.....	.....	.....
Gary Ind.	.....	.....	.....	.....	Hulett unloader. Three 5000-ton sintering lines	44-In. slabbing mill. 160-In. plate mill improvement. Hot strip mill	Cold mill	Electrolytic tinning line (c)	.....	.....
Homestead District Works Munhall, Pa.	.....	(365,000)	Open hearth improvements	.....	.....	.....	.....	.....	Heat treat line (c)	Open hearth precipitators
Houseville, Pa.	.....	.....	.....	.....	.....	Three 5000-ton sintering lines	.....	.....	.....	.....
Irvin Works Dravosburg, Pa.	.....	.....	.....	.....	.....	.....	.....	.....	Slab heating furnace	.....
South Works South Chicago, Ill.	.....	.....	.....	.....	One 5000-ton sintering line	Structural mill. Billet mill	.....	.....	.....	.....
American Steel & Wire Div. Cuyahoga Works	.....	.....	.....	.....	.....	.....	.....	Wire drawing and heat treating facilities. 37-In. Sendzimir cold rolling mill	.....	.....

PARTIAL LISTINGS OF ANNOUNCED EXPANSION PLANS—1957 (CONTINUED)

Company and plant	Cost	Additional ingot capacity, tons	Steelmaking facilities	Additional iron capacity	Ore preparation	Hot mills	Cold mills	Finishing facilities	Heating furnaces & pits	Miscellaneous
Waukegan Works	.....	.....	.....	.....	.....	.....	.....	Heat treating facilities. Facilities for manufacture of prestress strand	.....	.....
Worcester Works	.....	.....	.....	.....	.....	.....	.....	Electric cable producing facilities	.....	.....
Columbia-Geneva Steel Div.	.....	382,000	Rebuild open hearths (c)	.....	.....	.....	.....	.....	Two batteries soaking pits	Ammonia plant (c)
National Tube Div.	.....	.....	.....	.....	.....	.....	.....	.....	Three 3-hole soaking pits	One coke oven battery
Tennessee Coal & Iron Div.	.....	.....	.....	.....	.....	.....	Temper mill	.....	.....	.....
Wallingford Steel Co., Wallingford, Conn.	.....	.....	.....	.....	.....	.....	26-In. Sendzimir mill	.....	.....	Metallurgical laboratory
Washington Steel Corp. Washington, Pa.	$995,000	.....	.....	.....	.....	.....	.....	48-In. Continuous strip grinder. 18-In. slitting line. One continuous Koleen salt-descaling line (c)	Modification of 3-strand annealing line furnace to increase capacity by 30 per cent	Two resquare shears. Acid disposal plant. Adding 45,000 sq ft of new building (c)
Wheeling Steel Corp.	$50,000,000									
Benwood, W. Va.	.....	.....	.....	.....	.....	.....	.....	Consolidate pipe finishing	.....	Pipe warehouse
Steubenville, Ohio	.....	.....	.....	.....	.....	Revamp hot strip mill (c)	Temper mill	.....	One row pits	Scarfing machine (c)
Yorkville	.....	.....	.....	.....	.....	.....	5-Stand tandem mill (c). 2-Stand temper mill (c). Revamp temper mill	Cleaning line (c). Revamp washing line. Revamp pickle line. Trimming line	Stationary & continuous annealing	.....
Youngstown Sheet & Tube Co.	$85,000,000									
Indiana Harbor, Ind.	.....	200,000	.....	.....	Sintering line	No. 3 Seamless tube mill (c)	Tin mill (c). 2-Stand temper mill (c)	Electrolytic tinning line (c)	Continuous annealing furnace (c). Batch annealing (c)	.....
Youngstown, Ohio	.....	280,000	.....	.....	.....	Upset mill	.....	.....	.....	.....
Partial Totals	$2,455,080,000	15,574,460 (tons)								

FOREIGN PLANTS

Canada's booming steel industry increased its ingot capacity from 3,694,000 net tons in 1948 to 5,984,700 net tons in 1957. Steel ingot production in 1957 totaled 5,400,000 net tons. Canadian plants can thus now supply some 62 per cent of Canada's over-all steel requirements, and this is scheduled to grow still further. At present Canada can supply all of its tinplate requirements. It has continuous hot strip mills, cold reduction mills, electrolytic tinning lines, continuous galvanizing lines, plate mills and continuous annealers.

It was estimated also that steel production in Canada would be doubled by 1980, at which time steel production of about 11,800,000 tons will be in order. An estimated outlay of some $9,900,000,000, not including money spent for plant replacement, will be required.

At the present time there are some 28 companies, including subsidiaries, in Canada. Four fully integrated mills form the core of the industry and have 90 per cent of the ingot capacity. The remaining companies manufacture finished products from semi-finished steel. The four integrated plants are Steel Company of Canada, Ltd., Hamilton, Ont.; Algoma Steel Corp. of Sault Ste. Marie, Ontario; Dominion Steel & Coal Corp. Ltd., Sidney, Nova Scotia; and Dominion Foundries & Steel Ltd., Hamilton, Ontario. More than 50 per cent of the ingot capacity in Canada is now near Hamilton.

A new company was formed to make rolled steel wheels in Canada, to be known as the Canadian Steel Wheel, Ltd. It was formed by Canadian Steel Foundries, Ltd. and English Steel Corp. Ltd. of Sheffield, England. The plant is located in Montreal, and is scheduled to be in operation by mid-1958. Annual capacity of 200,000 wheels is planned.

There were also rumors that a new integrated steel mill is being planned for Canada in the Montreal area.

A new seamless tube mill was put into operation in Canada at Sault Ste. Marie, Ontario, by the Mannesmann Tube Co. Ltd. Annual capacity is rated at 225,000 net tons. This mill started production on two products—seamless casing for oil and gas wells and seamless line pipe. Pipe is being produced as plain end pipe with a size range of 4.5 through 10.75 in. OD, and threaded line pipe in a size range of 4 through 10 in. OD. This company will receive its steel from Algoma Steel Corp. which is a short distance away from the tube plant.

A German company which has been active in the

Canadian industry is the Phoenix-Rheinrohr AG, which owns 100 per cent of Canadian Western Pipe Mills, Ltd. at Port Moody in British Columbia, a plant which went into production in 1955. In September, 1956, the company started production at the Alberta Phoenix Tube & Pipe, Ltd., near Edmonton, Canada, a new plant built at an estimated cost of $6,500,000 in partnership with Canadian interests. The new plant has a capacity of 150,000 tons annually. Pipe is produced in sizes ranging from 3 to 12 in. in diameter with thicknesses up to ⅜ in. In July, 1957, the Alberta Phoenix Tube & Pipe, Ltd. announced plans to expand the product range to 16-in. line pipe, and casing from 16 in. down to 4½ in. OD.

A new $10,000,000 electric-weld tube mill also started production this year at Welland, Ontario, at the plant of the Welland Tubes, Ltd. This mill has an annual capacity of 200,000 to 300,000 net tons in sizes ranging from 20 to 36 in. OD. This is Canada's first "big inch" pipe mill.

Page-Hersey Tubes, Ltd. started construction on a new $5,000,000 electric-resistance weld steel pipe mill for their Welland, Ontario, plant. The new mill will manufacture steel pipe from 2⅜ to 8⅝ in. in diameter and is scheduled for production early in 1958.

Dominion Foundries & Steel, Ltd. started construction on a 45-oven coke battery at its Hamilton works. The new battery will increase the firm's coke making capacity by 75 per cent and will be able to carbonize 1045 net tons of coal a day.

In Mexico, production of ingots has been going up quite rapidly each year. Present plans call for ingot production of 1,606,000 net tons by 1960 and 2,200,000 net tons by 1965. This compares with 952,000 net tons in 1956. The following are some of the proposed expansion plans for Mexico:

Altos Hornos de Mexico, S.A. — Montclova

1. Two more 156-ton open hearths.
2. A four-high tandem hot mill.
3. A second 56-in. cold reversing sheet mill.

Under construction at the present time are a 1100-ton per day sintering plant, two 156-ton open hearths, a 40 x 96-in. blooming mill and a 16½ and 53 x 56-in., four-high reversing cold mill.

Cia Fundidora de Fierro y Acero de Monterrey, S.A.— Monterrey

1. A third blast furnace, 1500-ton daily capacity.
2. Two additional open hearths.

Under construction in a $65,000,000 program are two 275-ton open hearths, two six-hole soaking pits, a 46 x 114-in., high-lift blooming and slabbing mill, a cross-country billet mill, a combination five-stand plate and 66-in. strip mill, a four-high reversing cold mill, skin pass mills. A new plant will be operated as a subsidiary called Aceros Planos de Monterrey.

La Consolidada, S.A. — Piedras Negras

1. Enlarged blast furnace.
2. Enlarged open hearth.
3. Installation of ingot mold foundry.

Under construction is an 80-ton open hearth.

Hojalata y Lamina, S.A. — Monterrey

1. Blooming mill.
2. Plate mill.
3. Tandem hot mill.
4. Tandem cold mill.
5. Continuous annealing furnace.
6. Continuous annealing line.

Units under construction at this plant are one four-high reversing mill, four soaking pits, one heavy and one light gage shearing line, one cleaning line, eight annealing furnaces and one 75-ton electric furnace.

A new steel mill is under construction at El Cotorro near Havana, Cuba. Estimated cost is $12,000,000 and the plant is being constructed by the newly formed Compania Antillana de Acero. Some of the components of the plant are a blooming mill, a billet mill, and two rolling mills. Operation of the plant is expected by the middle of 1959. Primary production of the plant will be corrugated bars for reinforced concrete construction.

The steel plant being built in Venezuela has been increased in scope, and the value of the project has gone from $200,000,000 to $343,000,000. It calls for an expansion of the plant's initial ingot capacity from 464,000 to 770,000 short tons. Ultimate capacity in the plant is to be 1,320,000 tons. Included in the program are four 305-ton open hearth furnaces, four 2-hole soaking pits, a 44-in. blooming mill with an 8000-hp drive. Initial operation is planned for the first half of 1958, with full production in 1960. Products are to be rails, reinforcing rods, structural shapes and wire products. Flat products will be added in the next phase.

The plant will use low shaft electric pig iron smelting furnaces rather than conventional blast furnaces. Nine electric resistance units, each of 220-ton capacity, make up one of the largest installations of its kind. These furnaces will require 275,000 kva.

An American company was awarded a contract for the engineering and construction of a 220-ton open hearth furnace to be constructed for the Compania de Acero del Pacifico at Santiago, Chile. This new furnace is part of an over-all $26,000,000 improvement program. The unit is scheduled to be in operation in mid-1959.

The American Iron & Steel Institute reported that western Europe is well on its way to doubling its pre-war steel capacity by 1960, at which time its steel-making capacity will be about 122,000,000 tons annually.

Some of the changes which will come with this will be a marked increase in exports of steel from western Europe, in addition to large gains in steel consumption. Europe will also become more greatly dependent on non-European suppliers of raw materials, particularly iron ore from the western hemisphere. It is estimated that of the 26,000,000 to 28,000,000 tons expansion which will occur between 1956 and 1960, some 9,000,000 net tons will occur in west Germany, 6,000,000 tons in the United Kingdom, 4,000,000 tons in France, and a total of 7,000,000 tons in Italy, Belgium, Spain, Sweden and Austria.

Practically all European companies are expanding their capacity, putting in modern equipment and setting up equipment for new products. In addition, a number of intensive research programs are under way to solve the problems of steel production, peculiar to the European area. If any general trend is evident, it is to more automatic, continuous production techniques. Emphasis on expansion has been on the flat products.

TABLE I
1957 STEEL PRODUCTION

European Steel Production—Net Tons

Country	*1956*	*1957*
USSR	54,500,000	56,000,000
Western Germany	25,507,900	26,254,800
United Kingdom	23,090,100	24,757,400
France	14,738,900	15,173,400
Belgium	7,012,500	7,000,000
Italy	6,498,800	7,170,900
Poland	5,515,400	5,800,000
Czechoslovakia	5,400,000	5,600,000
East Germany	3,000,000	3,200,000
Luxembourg	3,801,600	3,854,400
Saar	3,711,400	3,773,500
Sweden	2,650,000	2,700,000
Austria	2,290,000	2,600,000
Spain	1,370,000	1,800,000
Hungary	1,600,000	1,500,000
Netherlands	1,146,200	1,274,300
Yugoslavia	1,000,000	1,400,000
Rumania	900,000	1,100,000
Others	2,360,000	2,600,000
Totals	166,092,800	173,558,700

American Steel Production—Net Tons

Country	*1956*	*1957*
Brazil	1,500,000	1,600,000
Canada	5,300,000	5,400,000
Mexico	648,000	700,000
United States	115,216,000	113,000,000
Totals	122,664,000	120,700,000

Australian, African and Asian Steel Production—Net Tons

Country	*1956*	*1957*
Australia	2,900,000	3,400,000
China	5,000,000	5,500,000
India	1,947,000	1,900,000
Japan	12,243,000	14,000,000
South Africa	1,700,000	1,800,000
Totals	23,790,000	26,600,000
Grand Total	312,546,800	320,858,700

Estimated steel production in Europe is given in Table I.

The estimate for total steel production in the world in 1957 is about 321,000,000 net tons.

In Great Britain, The Iron and Steel Board completed a special report reviewing the probable demand for steel up to 1962 and reviewed plans to meet this demand. The conclusion indicates that some 26,400,000 net tons will be needed by 1962 for home consumption and 5,500,000 net tons for export, or a total of 31,900,000 tons of finished steel. This estimate is based on an increase in demand of 3.75 per cent per year.

To make this amount of steel, some 20,900,000 tons of pig iron will be needed, requiring 23,100,000 tons of home or British ores, and 24,200,000 tons of imported ores. This is on the assumption that 55,000,000 tons of scrap will be available to supplement the pig iron. A good coke rate is assumed in their calculations, as they estimate 1680 to 1800 lb per ton for basic, and 1800 to 1850 lb for all grades of pig iron compared with 2212 lb used in 1956. The British estimate that some $1,440,000,000 will be needed to handle the program.

The existing plans filed with the Board will raise capacity up to about 30,800,000 net tons by 1962. However, several proposals have not been definitely settled, including major developments by Richard, Thomas & Baldwins Ltd., for extensions to their existing works at Ebbw-Vale and at Redbourn, and a new iron and steel plant at Newport (Monmouthshire) to make semi-finished steel.

Under the Iron and Steel Board program, pig iron production is to be markedly increased. The program is indicated by Table II.

Twelve new blast furnaces are in the course of construction or planning. Some of these units will replace smaller old furnaces. They are at the plants of Bairds & Scottish Steel Ltd., Colvilles, Ltd., at Ravenscraig Works, The Millon & Askam Hematite Iron Co., Ltd., Consett Iron Co., Ltd., South Durham Steel & Iron Co., Ltd. (West Hartlepool and Cargo Fleet Works), John Lysaght's Scunthorpe Works, Ltd., The Lancashire Steel Corp., Ltd., and the Steel Company of Wales, Ltd.

TABLE II
IRON PROGRAM—GREAT BRITAIN

Company	*Production 1956, net tons*	*Estimated production 1962 from existing capacity and schemes approved by the Board,* net tons*
Bairds & Scottish Steel Ltd.	165,000	310,000
Barrow Ironworks, Ltd.	450,000	620,000
Colvilles, Ltd.	830,000	1,610,000
Consett Iron Co., Ltd.	790,000	1,460,000
Dorman Long (Steel) Ltd.	1,340,000	2,000,000
Guest Keen Iron & Steel Co. Ltd. (Cardiff)	600,000	670,000
The Lancashire Steel Corp., Ltd.	285,000	530,000
John Lysaght's Scunthorpe Works, Ltd.	430,000	625,000
The Millom & Askam Hematite Iron Co., Ltd.	335,000	450,000
Shelton Iron & Steel Ltd.	260,000	320,000
South Durham Steel & Iron Co., Ltd. (West Hartlepool and Cargo Fleet)	550,000	1,600,000
The Stanton Ironworks Co., Ltd.	500,000	670,000
The Staveley Iron & Chemical Co., Ltd.	325,000	325,000
The Steel Co. of Wales, Ltd.	1,190,000	2,240,000
Stewart and Lloyds, Ltd. (Corby)	750,000	840,000
Stewart and Lloyds, Ltd. (Bilston)	330,000	340,000
Stewart and Lloyds, Ltd. (Wellingboro)	230,000	280,000
John Summers & Sons Ltd. (Shotton)	720,000	1,120,000
Richard Thomas & Baldwins, Ltd. (Ebbw-Vale)	625,000	620,000
Richard Thomas & Baldwins, Ltd. (Redbourn)	335,000	375,000
The United Steel Companies, Ltd.:		
Appleby-Frodingham Steel Co. Branch	1,260,000	1,650,000
Workington Iron & Steel Co. Branch	450,000	545,000
Totals	12,750,000	19,200,000
Other companies	1,990,000	2,200,000
Total all companies	14,740,000	21,400,000
Possible additional output from development schemes under consideration by the Board		200,000
Different types of iron (included in totals above)	11,180,000	†
Basic pig iron		
Hematite pig iron**	1,730,000	†
Foundry pig iron and blast furnace ferro-alloys	1,830,000	†
Total	14,740,000	—

* Assuming almost all the old blast furnaces are still in production unless they are being directly replaced by new furnaces.

** Approximately half of the hematite pig iron is consumed in steelmaking.

† Several furnaces make foundry iron, or hematite, or sometimes basic, according to market conditions, and it is not practicable to give separate figures for 1962.

TABLE III
STEEL PROGRAM—GREAT BRITAIN

Company	*Production 1956, net tons*	*Estimated production 1962 from present capacity and approved schemes, net tons*
Colvilles, Ltd. (and subsidiary companies)	2,250,000	2,800,000
Consett Iron Co., Ltd.	995,000	1,680,000
Dorman Long (Steel) Ltd.	2,330,000	2,800,000
English Steel Corp., Ltd.	380,000	590,000
Guest Keen Iron & Steel Co., Ltd. (Cardiff)	785,000	950,000
The Lancashire Steel Corp., Ltd.	515,000	780,000
John Lysaght's Scunthorpe Works, Ltd.	645,000	810,000
The Park Gate Iron & Steel Co., Ltd.	410,000	450,000
The Patent Shaft & Axletree Co., Ltd.	140,000	340,000
John Summers & Sons Ltd. (Shotton)	1,080,000	1,850,000
Richard Thomas & Baldwins Ltd. (Redbourn)	520,000	530,000*
Richard Thomas & Baldwins Ltd. (Ebbw-Vale)	780,000	925,000*
Richard Thomas & Baldwins, Ltd. (W. Wales and other works)	800,000	820,000
Round Oak Steel Works, Ltd.	353,000	560,000
South Durham Steel & Iron Co., Ltd. (West Hartlepool and Cargo Fleet)	925,000	2,150,000
The Steel Company of Wales, Ltd.	2,000,000	3,350,000
Stewarts & Lloyds, Ltd. (Corby)	1,100,000	1,260,000
Stewarts & Lloyds, Ltd. (Bilston)	360,000	450,000
Stewarts & Lloyds, Ltd. (Scottish Works)	245,000	340,000
The United Steel Companies, Ltd.:		
Appleby-Frodingham Steel Co. Branch	1,200,000	1,520,000
Steel Peech and Tozer Branch	1,170,000	1,340,000
Workington Iron and Steel Co. Branch	285,000	340,000
Samuel Fox & Co. Ltd.	350,000	500,000
Totals	19,618,000	27,135,000
Other companies	3,500,000	4,000,000
Total all companies	23,118,000	31,135,000
Possible net additions from development schemes under discussion		1,200,000

* These estimates do not include the additional production which might come from developments at present under construction.

A comparison of the program for steel production is given in Table III.

The first oxygen blown converter in Great Britain will soon be in operation at the Corby Works of Stewarts & Lloyds, Ltd. Facilities for oxygen blowing are also being installed at the Ebbw-Vale Works of Richard Thomas & Baldwins, Ltd. The new bessemer shops proposed for The Steel Company of Wales, Ltd., and for Consett Iron Co. Ltd., are making provisions for oxygen blowing. Oxygen is also being used in a number of plants for prerefining blast furnace metal before it goes to the open hearth furnace.

As far as the oxygen converter is concerned, the method developed in Austria is not apt to be adopted to as great a degree in the United Kingdom as in the United States because of its requirements for the use of low phosphorous iron which is seldom made in Great Britain. The rotor process developed in Germany and the Kal-Do process developed in Sweden have aroused more interest because they seem to be able to handle high phosphorous iron.

Table IV lists some of the major programs under way or completed this year in Great Britain.

Throughout the year, there was a rash of working agreements set up between American companies and foreign firms. As an example, Republic Steel Corp. at Cleveland, in conjunction with Fiat of Italy are engaged in the construction of $126,000,000 steel plant at Vado Ligure, near Genoa. Republic is furnishing technical assistance for three years. Another Italian company—Cornigliano, a basic Italian steel producer—is working with an American company for a new blooming mill to be built at Genoa. Republic Steel also has an advisory arrangement with Die Kloeckner-Werke AG Duisburg, Germany, on a new wide strip mill to be built at Bremen.

It is reported also that Phoenix-Rheinrohr AG of Dusseldorf has been having discussions with Bethlehem Steel Co. on future cooperation, under which an exchange of experience and technical advice is contemplated.

Armco has been working for some time with August Thyssen-Huette in a major expansion project which in 1957 had restored the company to its prewar steel ingot capacity of 2,640,000 net tons and at the end of the year was up to 3,080,000 net tons. Annual capacity for pig iron is 2,200,000 tons, some 40 per cent higher than before the war.

Combinations between steel plants are also under way in Germany. August Thyssen-Huette took over, through a stock exchange, the Deutsche Edelstahlwerke in Krefeld, West Germany, which is the largest producer of stainless and high grade alloy steel in West Germany. Thyssen-Huette also purchased a minority ownership of the Huttenwerke Siegerland which is Europe's largest sheet steel producer.

Phoenix-Rheinrohr AG of Dusseldorf, West Germany, put into operation a new blast furnace at an estimated cost of $7,500,000 at the plant located in the town of Ruhrort-Meiderich. The Phoenix-Rheinrohr company also plans to expand ingot steel production from the present 2,650,000 net tons to 3,300,000 tons by 1960.

It is estimated that France will increase its annual steel production to 20,000,000 tons by 1961, an increase of about 20 per cent. Expansion will require about $1,200,000,000 of capital which will be put up by private iron and steel companies.

France has authorized construction of the first steel plant on the sea coast. The plant, which will be named the Societe Dunkerquoise de Siderurgie, is scheduled to produce about 500,000 tons of steel per year. First construction will be on a single blast furnace with a capacity of 1200 to 1500 tons daily, designed for operation on rich imported ores. The plant will be an

TABLE IV
EXPANSION PROGRAM—GREAT BRITAIN

Company	*Description*	*Estimated completion date*
Bairds & Scottish Steel Ltd.	Additional coke ovens, replacement of 5 old blast furnaces with 2 modern furnaces, sinter plant and ancillary equipment.	1960 (except for second blast furnace)
Arthur Balfour & Co., Ltd.	Improvement and extension of steelmaking facilities.	Late 1958
Barworth Steel Works, Ltd.	New melting shop with ancillary shop.	1961
The Britton Ferry Steel Co., Ltd.	New open hearth furnace and ancillary equipment.	End 1958
Brymbo Steel Works, Ltd.	Modernization of steelmaking facilities.	Late 1958
Colvilles, Ltd.	Electrification of and improvements to section and rod mills.	1958–59
Consett Iron Co., Ltd.	Additional open hearth furnace.	Completed
Consett Iron Co., Ltd.	Coke ovens, sinter plant, blast furnace, melting shop and plate mill.	1962
Charles Cooper (Tipton) Ltd.	Cold rolling mill, pickle line and annealing furnaces.	Completed
Dorman Long (Steel), Ltd.	Modernization of steel making facilities at Cleveland Works.	Mid 1958
English Steel Corp., Ltd.	New open hearth melting shop and facilities for the production of heavy forgings and castings.	1963
	Additional electric furnace.	1958
Samuel Fox & Co., Ltd.	Combined bar and rod mill and heat treatment dept.	Late 1957
	New electric arc furnace and replacement of billet mill.	Early 1958
Guest Keen Iron & Steel Co., Ltd.	Additional soaking pits and replacement of existing pits.	Mid 1957
	Froth flotation plant.	Mid 1957
	Sinter plant.	Early 1958
Graham Firth Steel Prod., Ltd.	Cold rolling mill and annealing furnaces.	Late 1957
John Lysaght's Scunthorpe Works, Ltd.	New coke ovens, sinter plant and blast furnace and ancillary equipment; additional mill stands and cooling beds, and alterations to rod mill.	1959–1960
The Millom & Askam Hematite Co., Ltd.	Replacement and enlargement of blast furnace.	End 1957
The Patent Shaft & Axletree Co., Ltd.	Extension and modernization of melting shop, installation of new slabbing and blooming mill and plate mill, and general improvements to services at Brunswick Works.	Early 1959
Richard Thomas & Baldwins, Ltd.	Conversion of bessemer plant to oxygen steam blowing at Ebbw-Vale.	Early 1958
Richard Thomas & Baldwins, Ltd.	Remotoring and renovation of hot strip mill at Ebbw-Vale.	Late 1959
Richard Thomas & Baldwins, Ltd.	First two stages of rebuilding No. 1 battery of 65 coke ovens at Ebbw-Vale.	1st stage—17 ovens, completed. 2nd stage—13 ovens, late 1957
Richard Thomas & Baldwins, Ltd.	Additional pickle line at Ebbw-Vale.	Completed
Round Oak Steel Works, Ltd.	Additional steelmaking capacity.	Mid 1958
The Steel Co. of Wales, Ltd.	Additional annealing capacity at Trostre.	Completed
The Steel Co. of Wales, Ltd.	Additional tinning facilities at Velindre and Elba Works.	Late 1957
The Steel Co. of Wales, Ltd.	Plant for manufacturing of low loss electrical sheet at Newport.	Late 1957
The Steel Co. of Wales, Ltd.	New coke ovens, sinter strand and blast furnace at Margam. New melting shop, conversion of slabbing mill, new soaking pits, slab furnace, pickle line, annealing equipment and cold mill at Abbey. Electrolytic tinning line at Velindre.	1959
John Summers & Sons, Ltd.	Expansion of steelmaking, rolling and finishing capacity.	1959
South Durham Steel & Iron Co., Ltd.	Second new blast furnace with ancillary equipment at West Hartlepool.	Mid 1959
South Durham Steel & Iron Co., Ltd.	Extension of ore handling plant, new coke ovens, blast furnace, open hearth melting shop, slabbing mill and plate mill at West Hartlepool.	Late 1960
Stewarts & Lloyds, Ltd.	Modernization of heavy rolling department at Corby.	1959
Stewarts & Lloyds, Ltd.	Rebuilding and extension of coke ovens and ancillary equipment at Corby.	1966
United Steel Companies, Ltd.:		
Appleby-Frodingham Steel Co. Branch	New blowing equipment, ore preparation plant and open hearth furnace.	Completed
	Extension to coke oven plant.	Late 1958
	New plate finishing mill with buildings and ancillary equipment.	Mid 1958
Steel Peech & Tozer Branch	Replacement of soaking pits.	Completed
	Renovation of 30-in. mill and slab mill.	Late 1957
	New pickling plant.	Mid 1957

integrated unit with open hearths and plate mills. An oxygen-blown converter is also scheduled.

Early in 1959, the Italian steel industry loses the tariff protection granted to it under the European coal and steel community, and in preparation for this has added extensively to and modernized its steelmaking capacity. Production of ingots in 1957 totaled about 7,200,000 net tons compared with about 6,500,000 tons in 1956. As a result, Italy, traditionally a steel importer, has become a steel exporter. One of its biggest handicaps is the production of pig iron, with present capacity just over 2,200,000 tons. Present plans provide for an increase up to 3,900,000 tons by 1960 which will still require some imports. Annual rolling capacity in Italy is about 10,000,000 tons.

Up to the present time practically all of Italy's pig iron capacity has been owned by the two state-controlled steel concerns—Finsider and Cogne. However, private enterprises will be responsible for the new steel plant to be built in Vado Ligure by Fiat Motor Co. in conjunction with Republic Steel Corp., and also the privately owned Falck Co. The Vado plant will have two blast furnaces with an annual capacity of 1,000,000 net tons. The steel division will have a capacity of 770,000 tons.

Political pressure is under way to get Finsider to build a completely new integrated steel plant in southern Italy, probably either in Taranto or in Sicily. The cost of the new plant has been estimated at up to $280,000,000. Initial output would be 1,100,000 net tons.

An American concern was awarded the contract for the design, procurement and construction of a blast furnace for ILVA or Alti Forni E Acciaieri D'Italia of Genoa, Italy, a subsidiary of Finsider. The blast furnace will be constructed at Piombino, Italy. Another blast furnace is being constructed at the Bagnoli plant near Naples. The blast furnace will have a hearth diameter of 22 ft and will have a production capacity of 1000 net tons of iron per day. The company operates two other blast furnaces at the plant, each with a capacity of 800 net tons per day.

The first large multiple stand rolling mill to be erected at any of the Benelux countries went in operation at Liege, Belgium, at the plant of the Society Anonyme Metallurgique d'Esperance Longdoz. This is a three-stand, four-high mill rated at 400,000 tons per year of cold rolled steel. Design has been made for the addition of a fourth stand at a later date. The mill will roll 52-in. strip down to 0.024 in. at delivery speeds up to 900 fpm.

Several interesting reports were given during the year by steel plant operators and metallurgists who had the opportunity to visit the Soviet Republic during the year. These reports, along with "Sputnik," indicate that there are things to be learned from the Russians in some fields. In making any comparisons, however, it must be emphasized that developments in the Russian steel industry are accomplished without regard to capital or the operating cost of the new equipment, factors which no American steel plant can ignore.

All reports indicate that the Russians are getting fine performance from their blast furnace plants. Productions up to 2500 tons a day are obtained from furnaces with 26.5-ft diameter hearths. This is not entirely due to better ore, but to more thorough preparation of the raw material and higher blast temperatures. They also plan on using a completely beneficiated and prepared ore burden which may be self-fluxing.

It is reported that the Russians are about on a par with the U. S. in steelmaking, but lag in rolling and finishing, and in the production of high alloy and stainless steels.

An unusual feature in Russian operation is that they have a full scale ntegrated plant whose principal job is to experiment with advanced techniques and practices. The results of this plant's operation are made available to the whole Russian steel industry.

It has been estimated that of the 1956 Russian output of 54,500,000 net tons, some 48,100,000 tons were open hearth steel, 4,200,000 were electric furnace and 2,200,000 tons were bessemer. It has been reported also that in the blast furnace, the average charge in the Russian furnace is 60 per cent sinter with a coke rate of about 1724 lb per net ton of iron. It is estimated by 1960 the countries of Eastern Europe will have a combined steel capacity of 96,000,000 net tons, including 75,000,000 tons in Russia. Russia plans by this time to produce 125,000,000 net tons of iron ore, 80,000,000 tons of sinter, 71,000,000 tons of coke, and 58,000,000 tons of pig iron.

The current plan for Russia also includes an 80-in. hot strip mill at Magnitogorsk, an 80-in. mill at Karaganda, a semi-continuous 67-in. mill at Voroshilov, and a 67-in. semi-continuous mill at Tcherepovets. These mills will give Russia a production capacity of over 12,000,000 tons of coils. In Poland, a continuous strip mill at Nowa Huta is expected to be in full production by 1960.

The steel industry in India will provide an interesting comparison of private plant operation pitted against operation by government-owned plants. The present 5-year plan for expansion of steelmaking in India will result in some 3,300,000 net tons of ingot capacity for private operators and some 3,300,000 net tons in three government-owned plants.

The program for privately owned plants raises finished products of Tata Iron & Steel Co. at Jamshedpur up to 1,650,000 net tons, the Indian Iron & Steel Co. at Asansol up to 900,000 tons, the Mysore Iron & Steel Works at Bhadravai in Madras up to 120,000 tons and rerolling companies throughout India will have some 780,000 tons. The proposed government-owned plants will have a capacity of 790,000 tons at Rourkela in Orissa, 825,000 tons at the plant at Bhilai in the Central Provinces and 825,000 tons at the Durgapur plant in Bengal. Thus, proposed total finished steel production will aggregate 5,000,000 net tons. The program closest to completion, largely handled by an American concern, is that being done for the Tata Iron & Steel Co. They are spending about a quarter-billion dollars to increase ingot capacity up to 2,200,000 net tons which will keep Tata the largest plant in India. The main items in the program are:

1. Two 26-oven coke batteries.
2. Rebuilding of three old coke oven batteries.
3. Ore preparation and sintering plant.
4. One new 28-ft blast furnace.
5. Seven new 220-ton open hearth furnaces.

6. One 46-in. blooming mill with soaking pits.
7. One continuous sheet bar and billet mill.
8. One medium and light structural mill.
9. One skelp mill.
10. One Fretz-Moon tube mill.
11. Revamp present plate mill.
12. Revamp present merchant mill.
13. Revamp present structural mill.
14. One slag/scrap recovery plant.

The three government-owned plants in India will be built by a German, a British and a Russian group. The Germans are building the plant in Rourkela. This 1,200,000 ingot ton plant will consist of the following:

1. Three 78-oven coke batteries.
2. Three 1200-ton blast furnaces.
3. A top-blown oxygen converter steel shop.
4. A hot strip mill.
5. Cold mills, galvanizing and tinplate equipment.

Part of this is scheduled for operation in 1959.

The Russians are building the plant at Bhilai which is scheduled to be in operation late in 1959 and which will have an ingot capacity of 1,200,000 tons. This plant will consist of the following:

1. Three 65-oven coke batteries.
2. Three 1250-ton per day blast furnaces.
3. One open hearth shop.
4. One blooming mill.
5. Heavy medium structural mills.
6. Merchant bar mills.

The British are constructing a plant at Durgapur. This will also have an ingot capacity of 1,200,000 tons. This plant will consist of:

1. Three 78-oven coke batteries.
2. Three 1375-ton per day blast furnaces.
3. Three open hearths.
4. Mills for rolling of medium and light sections.
5. Wheel and tire and axle plants.

This plant is scheduled for operation in 1960.

It is estimated that all three plants will cost a total of about $900,000,000 or about $270 per ton of annual capacity.

It was estimated that Japanese iron production in 1957 totaled 7,500,000 net tons, an increase of 13 per cent over the previous year. Steel ingot production totaled 14,000,000 net tons, about 12 per cent over the previous year. Hot rolled steel production totaled 11,000,000 tons. Production in Japan was held back somewhat by a series of strikes in October and November.

The Export-Import Bank of Washington loaned $10,300,000 to the Fuji Iron & Steel Co., Ltd., to purchase heavy rolling mill machinery in the United States. Included in the program are an 80-in., 4-high reversing cold mill and a 160-in., 4-high reversing plate mill. A continuous annealing furnace is also being put in.

RAW MATERIALS

In general, raw materials were no serious problem to the steel industry in 1957. The reduced rate of operations and the increased capacity on the part of raw material suppliers took the zip out of the frantic demand which has been in evidence for some materials since the war. Scrap, which has set new price records and which is perhaps one of the best barometers of the demand for steel, dropped from the record high prices in effect at the end of 1956. Ore was plentiful. Efforts to develop new supplies are still continuing, and great strides were made during the year in developing new supplies, in processing low grade ores and in setting up plants to process such ores. These developments are now emphasizing production of materials which may be more economical or desirable than those now used, rather than fixing attention on obtaining raw material primarily for the sake of meeting requirements.

There is no question that the developments in taconite and beneficiating ore which have been put into effect in the past few years will become standard operating procedure. Additional plants for preparing ores will undoubtedly be built as time goes on, since the existing supplies of high grade, direct shipping ores now on the Great Lakes, will disappear. However, it has been found that beneficiating has not only developed a material which can be used in the blast furnace, but has developed one which helps to increase the capacity of blast furnaces, thus relieving pressure for adding iron-making units. Several plants have found they can add enough to their iron production through improving their ores to keep added steelmaking operations in balance without adding new blast furnaces.

Proof of the greater availability of raw materials were a number of price cuts toward the end of the year. Lead, for example, dropped to as low as 13¢ a lb from almost 16¢ the previous year. Price of zinc was down to 10¢ a lb from about 13.5¢ the year before. Tin, which was $1.05 a year ago, dropped to under 89¢ in 1957, but at the end of the year went back up to about 96¢. Another material on which there was a big drop was copper, which was down to about 25¢ at the end of 1957 compared with 36¢ the year before.

Ore—Ore shipments were concluded fairly early in 1957 and a total of 94,600,000 net tons of Lake Superior ore were brought down by the seasons end the first week in December. Lake shipments in 1956 totaled about 87,000,000 net tons. Other shipments of ore in the United States totaled about 22,000,000 tons in 1957, compared with about 24,600,000 tons in 1956. Total imports in 1957 were about 36,000,000 net tons compared with slightly over 34,000,000 tons in 1956.

It is reported that in 1957, for the first time, the tonnage of concentrates were higher than direct shipping ores from the Mesabi area. It is expected that within a few years no ore will leave the district without some form of beneficiation. U. S. Steel's Oliver Iron Mining Division already treats all of its output.

Ore treatment varies a great deal. It may be as little as crushing and screening for ores which are higher than 50 per cent iron content to eliminate fines and to increase the iron content somewhat. In other cases it may involve crushing, screening, washing and recycling with ores under 50 per cent iron content. The more difficult and (leaner) ores may require high density concentration after washing, involving high density classifiers, magnetic separators, heavy media recovery, etc. Fines from all of these will probably go through a sintering plant.

A new ore supply may come from the work of the Granite City Steel Co. and another company who went into a joint venture for the purpose of exploring ore fields in the state of Missouri. The agreement also includes the development of mining properties.

A report from Russia is that two large iron ore deposits have been discovered which may be the largest in the world. They are supposed to be near Belgorod on the upper Donets river near Kharkov. One deposit is reported to be three miles long, over ½ mile wide and 600 ft thick.

A report was recently published in Canada bringing up to date the present status of ore in the Canadian North. Shipments of iron ore from Canada in 1956 amounted to 22,500,000 net tons compared with 16,300,000 net tons in 1955, a remarkable increase in one year. A proportion of this gain is due to the increased output by the Iron Ore Company of Canada from the mines in Labrador and Quebec.

The chief producers in Canada are Dominion Wabana Ore, Ltd.; Iron Ore Company of Canada; Quebec Iron and Titanium Corp.; Marmoraton Mining Co. Ltd.; Algoma Ore Properties; Noranda Mines, Ltd.; The International Nickel Co. of Canada, Ltd.; Steep Rock Iron Mines, Ltd.; Argonaut Mine Division of Utah Co.; and Texada Mines, Ltd. Producers who have projects under way and who will probably be in operation soon are Canadian Javelin, Ltd.; The Cartier Mining Co. Ltd.; The Hilton Mines; the Lowphos Ore, Ltd.; Canadian Charleson, Ltd.; The Caland Ore Co. Ltd.; and the Empire Development Co. Ltd.

Among the projects which have been completed is one by Dominion Wabana Ore, Ltd. at Wabana, Newfoundland. The Quebec Iron & Titanium Corp. at Soral, Quebec, is making desulphurized iron from ilmenite mined at Allard Lake, north of Havre Ste. Pierre, Quebec. The Iron Ore Company of Canada, near Knob Lake, is continuing its development program which is scheduled to produce 20,000,000 tons a year by 1960. In 1956, this company shipped 13,100,000 net tons to Seven Islands.

The Hilton Mines, which are about 40 miles northwest of Ottawa, built a beneficiation plant at a cost of $15,000,000 to upgrade a low grade magnetite into high grade iron ore pellets of 66 per cent iron content. Shipment started late in 1957. The Hilton Mines are a joint venture with the Steel Company of Canada controlling one-half through a subsidiary, and with Pickands Mather & Co. and Jones & Laughlin Steel Corp. controlling the other half. Pickands Mather & Co. is supervising and managing the construction and operation of the project. It is estimated that this mine will be able to produce a 15-year supply of about 660,000 tons per year of pellets containing 66 per cent iron.

In Ontario, the Marmoraton Mining Co., Ltd., is in its second year of operations. This is a subsidiary of Bethlehem Steel and has a capacity of about 1,650,000 net tons.

In 1956 Steep Rock Iron Mines produced over 3,300,000 tons of direct-shipping ores. Their development program is aimed at producing 6,000,000 net tons in the early 1960s in addition to the 3,300,000 tons which will be produced in the area leased to the Caland Ore Co. Ltd., a wholly owned subsidiary of Inland Steel Co. Canadian Charleson Ltd. is also operating in this area.

Sintering machines are getting bigger. Unit shown has a bed 8 ft wide and 104 ft long and can handle 2600 tons per day. Another machine with a bed 12 ft wide is being added at this plant.

A great deal of interest is being paid to the operations of the Quebec-Cartier Mining Co., which is a wholly owned subsidiary of United States Steel Corp. An announcement early in 1957 indicates that it will spend an estimated $200,000,000 to put into production iron ore holdings in the Mt. Wright area, about 300 miles northwest of Quebec city and 150 miles north of Shelter Bay on the St. Lawrence. This company has been actively exploring the area to the west of Wabush Lake. A second mine is reported to be 100 miles further north.

The program by Quebec-Cartier Mining Co. Ltd., includes a railroad about 150 miles long from Shelter Bay on the north shore of the St. Lawrence river, northward to the Mt. Wright area. Production is expected in 1961 at an annual rate of 3,300,000 tons and this is to be expanded to 11,000,000 net tons of ore or 5,500,000 tons of concentrated pellets by 1965. Reserves are estimated at over 825,000,000 net tons of low grade (30 to 35 per cent) ore.

Other companies engaged in large scale explorations west of Wabush Lake are Jones & Laughlin Steel Corp., Pickands Mather & Co., Iron Ore Company of Canada, Steel Company of Canada, and Cleveland-Cliffs Iron Co.

At the northern end of the Quebec-Labrador iron-bearing area, west of Ungava Bay, extensive studies and exploration have been made by two companies: the Atlantic Iron Ore, Ltd., and International Iron Ore Co., Ltd., controlled by Cyrus S. Eaton, Oceanic Iron Ores of Canada and Consolidated Fenimore Iron Mines. It is reported that this area has extensive low grade reserves of iron-bearing material which run from 28 to 36 per cent iron, consisting of magnetite, hematite and siderite.

In Ontario, the Jalore Mining Co., Ltd., a subsidiary of Jones & Laughlin Steel Corp., exercised its option on an iron property in Boston Township, six miles southwest of Kirkland Lake.

The operation at Quebec Iron & Titanium Corp. is a

combination which produces from ilmenite raw material for titanium as well as for iron. This plant has five electric smelting furnaces in operation. Early in 1957, the company announced an expansion program which will increase production some 60 per cent, and will include three new smelting furnaces. When this is complete, the plant should be able to produce over 220,000 tons annually of desulphurized iron.

Canadian Javelin, Ltd., holds a 4700 sq mi concession in the Wabush Lake area of Labrador immediately south and adjacent to the Labrador concession of the Iron Ore Company of Canada, Ltd. On the basis of exploration, the company estimates reserve tonnages of over 1,100,000,000 net tons with about 36 per cent iron. About 40 miles of spur line will be needed to connect the deposits around Wabush Lake to the Quebec North Shore and Labrador Railway. Permission to build such a railroad was granted to the company by the Newfoundland legislature. In October, 1956, Canadian Javelin made a lease agreement with Pickands Mather & Co. and the Steel Company of Canada for a large body of iron ore in west central Labrador, which is estimated will yield 220,000,000 tons of concentrates through open pit mining. The Pickands Mather group also agreed to purchase in the period 1959 to 1964 up to 2,200,000 net tons per year of iron ore pellets which Javelin is to produce from its property. It is also reported that Canadian Javelin is signing agreements with a group of 15 German steel companies for the delivery of about 2,200,000 tons of ore per year.

The Lowphos Ore, Ltd., a wholly owned subsidiary of National Steel, is developing a property at Moose Mountain, 35 miles north of Sudbury, Ontario. It will be operated by open pits to produce 550,000 tons of ore concentrates a year. Initial shipment is expected in 1958.

New sintering plants, of course, will remain an important part in ore preparation. It is reported that some 11 sintering plants with 16 lines are now either being planned or constructed and should come into operation by 1959. These will have an annual capacity of about 21,000,000 tons. Two of the plants will be rated in excess of 4,500,000 tons of sinter per year. Of these plants, it is reported there will be eleven 96-in. wide machines, three 72-in. wide machines and two 144-in. wide machines.

As of January, 1957, sintering capacity in the United States and Canada was about 38,000,000 tons, but in 1959 it is to increase to 60,000,000 tons. Practically all of these lines are being installed close to the blast furnaces where they can be under the control of blast furnace management. Thus the blast furnace operator can have the sinter either hard-burned or soft-burned, whereas shipping sinter must be hard burned. Only machines to be used for sintering magnetite concentrates are likely to go near the mines.

One company has developed another new method for pelletizing and heat-treating magnetites. The process has four steps: forming the pellets in a ball pan or drum, drying the pellets on a moving grate, heating (partially oxidizing) the pellets, and burning of the pellets in a short rotary kiln. The process begins with the forming of ½- to ¾-in. diam pellets from finely ground moist magnetite concentrate. The conveyors transfer pellets to a traveling grate in a furnace which is divided into a drying chamber and a preheating chamber.

A sintering plant to be built in the Lorraine district of France will be a two-layer unit which will separate the calcining and sintering processes in the same strand. The top layer forms a true sinter and the bottom layer is for calcining only. Calcined material goes back to be recharged in the top layer, so most feed materials make two circuits. It is claimed that the process will reduce fuel and coke breeze requirements and result in stronger sinter.

Scrap—The most important price reduction in raw materials was in scrap. This went down to about $32 to $33 at the end of the year for No. 1 heavy melting grade at Pittsburgh, compared with $66 one year before.

The steel industry won a victory in Washington when the Department of Commerce announced a voluntary lid had been placed on the export of scrap material. Foreign buyers agreed that they would hold their imports to no more than 12 per cent higher than 1956's record total of 7,000,000 net tons. The industry had exerted pressure on Washington to bar scrap exports.

Ferroalloys—Production of ferroalloys which totaled about 2,600,000 tons in 1957, received a lift in September when operation started at a new plant in the Ohio valley. This plant will manufacture low carbon ferro-chromium alloys and various types of high carbon ferro-chromium and a complete series of ferro-chrome-silicon alloys. The plant was constructed by Vanadium Corp. of America.

Another ferroalloy plant went into operation in May in Rockwood, Tenn., to be operated by the Tennessee Products and Chemical Corp. Production of this plant will be about 200,000 tons a year. The plant will produce ferro-chrome, ferro-silicon, ferro-manganese and ferro-chrome-silicon in high and low carbon grades.

A $2,000,000 ferro-manganese pilot plant went into operation at Niagara Falls, capable of producing some seven tons of ferro-manganese and seven tons of pig iron daily. This plant was built to demonstrate a new process for the smelting of low grade manganese ores. Very optimistic claims have been made as a result of the pilot tests. High grade manganese ore costs about $60 a ton and it takes about two tons to make a ton of ferro-manganese. On the other hand, the raw low grade ores which can be used in this process will cost only $4 a ton and six tons are required. Plans are under way for a full scale production plant. The process uses selective reduction.

The Vanadium Corp. of America was granted a large manganese concession in northern Rhodesia, reported to contain large tonnages of unusually high grade manganese ore which can be mined on a low cost basis. This new concession supplements a smaller concession which has reserves estimated as sufficient to meet, for at least ten years, the company's current needs.

Nickel—The shortage of nickel became much less acute during the year and by the end of the year, nickel was in ample supply. As a result, spokesmen for the industry put on a campaign to persuade consumers that there can be a gradual restoration of the established usages for nickel that have been so limited in the past few years.

Supply is expected to outrun demand by 1961. In 1957 free world capacity was about 500,000,000 lb and consumption about 490,000,000 lb. By 1961 it is estimated that production capacity for nickel in the free world will be about 660,000,000 lb. In the United States, consumption of nickel in 1957 totaled about 250,000,000 lb, slightly under 1956.

One factor in future nickel demand is that the United States has refused to buy one company's expanded nickel output for stockpiling. The government, in making this decision, had among its reasons the fact that nickel expansion already under way will make a total of 440,000,000 lb of nickel available in the United States by 1961, up from the current level of about 300,000,000 lb.

The U. S. Government has an agreement with Freeport Sulphur to buy for the stockpile, if called upon, up to 271,000,000 lb of nickel and 23,800,000 lb of cobalt. U. S. also has the right to call upon 30 per cent of Freeport's planned capacity of 50,000,000 lb of nickel a year.

A subsidiary of Freeport Suplhur Co., the Cuban American Nickel Co., completed arrangements during the year to borrow slightly over $100,000,000 from banks and large nickel consumers for a major project for the production of nickel and cobalt. The metals will be produced at a plant to be constructed in Louisiana for refining ore concentrates from Cuba. Scheduled capacity of the plant will be 50,000,000 lb per year of nickel and 4,400,000 lb of cobalt. Production is due to begin in the middle of 1959.

The Bureau of Mines also ran a series of electric smelting tests on certain Cuban nickel ores and they reported that these can be used to give a low carbon ferro-nickel product which would be suitable for use in steel mills.

International Nickel Co. completed a 30-mile railroad to their deposits in northern Manitoba from the existing Canadian National Line which goes to Churchhill on Hudson Bay. This branch links the ore developments in the Mystery-Moak Lakes region with the main line. Development, costing $175,000,000 is scheduled for completion in 1960, at which time nickel will be produced at a rate of 75,000,000 lb a year.

International Nickel expects that by 1960 it will have an annual over-all nickel production capacity of 385,000,000 lb from its operation in the Sudbury district and from Manitoba. In 1955 Sudbury district production was about 280,000,000 lb.

Future nickel supply sources are indicated as follows:

Nickel Production Estimate, lb

	1956	*1960*
International Nickel	285,000,000	385,000,000
Falconbridge	43,000,000	55,000,000
Sherritt Gordon	19,000,000	20,000,000
Other Canadian suppliers	8,000,000	15,000,000
Nicaro Nickel, Cuba (U. S. Government controlled)	31,000,000	50,000,000
Hanna Nickel Smelting (Oregon)	14,000,000	17,000,000
S. A. Le Nickel (French, New Caledonia)	22,000,000	65,000,000
Miscellaneous	25,000,000	18,000,000
	447,000,000	655,000,000

Of the total free world supply of nickel in 1956, some 65 per cent went to the United States and 35 per cent to Canada, the United Kingdom and other countries. In 1957, some 60 per cent went to the United States.

Aluminum—In 1958, the aluminum industry is expected to operate at slightly higher rates than in 1957. It is estimated that the aluminum supply (primary, imports, recovery from scrap) for 1958 will be about 2,700,000 tons, up some 17 per cent from the 2,300,000 tons available in 1957. Primary production in the United States in 1957 was 1,640,000 tons or 38,000 tons below 1956. The price of basic aluminum pig went up one cent per lb.

However, expansion of the aluminum industry has proceeded so fast that capacity now existing or scheduled for completion in the near future is well ahead of projected demand.

Therefore, in October, Aluminum, Ltd., of Canada announced that it was halting an expansion of its Canadian ingot facilities that would have added 80,000 tons to its annual capacity by the end of 1958. This was a cutback in the program announced in August under which they planned to boost present smelting capacity from 770,000 tons to 850,000 tons.

Production of aluminum in 1957 by Alcoa amounted to 710,000 tons of primary aluminum. Installed capacity at Alcoa totaled about 792,500 tons at the close of 1957, or 42 per cent of the U. S. total.

In 1958, Alcoa plans to add 20,000 tons to its Point Comfort, Texas, smelter, and in 1958 it will start production at the Warrick, Ind., works where an ultimate capacity of 150,000 tons is planned.

Alcoa also completed its two-year $54,000,000 expansion program which was under way at Davenport, Ia. Among the new production units are a 100-in. cold mill for wide coiled aluminum sheet, a 160-in. hot mill, and foil rolling facilities with an annual capacity of 24,000,000 lb. An unusual unit is a plate stretcher which has a pulling force of 16,000,000 lb. The rolled product capacity at this plant is now up to about 36,000,000 lb per month. The foil mill equipment includes eight new 66-in. foil mills. The 100-in. cold finishing mill equipment will roll wider sheets to narrower tolerances. It fills the gap between the smaller cold mills up to 60 in. wide and the 144-in. mill that rolls heavier gages.

Kaiser Aluminum & Chemical Corp. started production in 1957 of the first units in a $200,000,000 project at Ravenswood, W. Va. The first units to start operation were cold rolling facilities, annealing units, slitters, shears and other auxiliary equipment needed for putting out light-gage sheet. The first foil mills, also started rolling early in the year. Ingot casting facilities and a hot mill started operation at the end of the summer. When completed in 1958, Ravenswood will have an annual capacity of 145,000 tons of primary aluminum, and 170,000 tons of rolled product.

Copper—Copper was in plentiful supply and the price dropped to lows which it had not reached for several years, around 25 to 26 cents a lb. Total capacity of copper in the free world at the end of 1957 was about 3,505,000 tons, of which 1,190,000 tons was available in the United States. This is about 200,000 tons more than was available in 1956. As the price of copper dropped during the year, several units were taken out of production, usually the high cost marginal units.

Zinc—Zinc production was up slightly, with total world production in 1957 being estimated at 3,141,000 short tons, compared with 3,082,000 tons in 1956.

Of this some 1,000,000 tons were produced in the United States compared with 995,000 in 1956.

Lead—Production of lead in 1957 totaled about 2,328,000 tons, compared with 2,301,000 tons in 1956. Of this 550,000 tons were produced in the United States compared with 542,000 tons in 1956.

Titanium—In the titanium industry, existing capacity has grown appreciably greater than needed for present shipments. Capacity of the industry at the end of 1957 was between 12,000 and 15,000 tons of titanium, and shipments totaled about 7000 net tons. One reason for this margin is the cutback in orders from military and defense applications. The industry is seriously studying non-military usages. By the end of 1957, production capacity of titanium sponge was believed to be up to about 41,000 tons.

In April, the Department of Defense issued a statement on the status of the titanium program. Report stated that substantial progress had been made toward commercial production of titanium sheet alloys with strengths 30 to 50 per cent greater than previous alloys. At the present time, four alloys are being developed by three titanium producers to meet requirements of ultimate tensile strength of 180,000 psi at room temperature, tensile yield strengths of 160,000 psi, and short-time ultimate tensile strength up to 130,000 psi at 800 F.

The Titanium Metals Corp. of America announced initial production in November from its new Toronto, Ohio, plant, which is the first facility devoted exclusively to the rolling and forging of titanium. The plant will provide fully integrated facilities, from sponge through forgings, billets and alloy sheet production.

In November, Crucible Steel Company of America bought out half-interest in Rem-Cru and became sole owners of this titanium company.

BLAST FURNACES

There were no revolutionary changes in blast furnace operation during the year, and no unusual developments. Changes were probably fewer on the blast furnace front than in any other stage of the industry, and there was less emphasis on new units. Capital cost of new furnaces has reached a point where it is more economical to use other methods to increase production. Also, activity in direct-reduction processes has led operators to sit back in the hope that perhaps one of these processes may provide a substitute for the blast furnace or provide supplementary equipment which will step up pig iron production from existing furnaces.

Although a great deal of work was done on direct reduction, and many reports were given on various processes for which many claims were made, no one process stands out enough to indicate that it might substitute for the blast furnace. A number of the processes are promising for plants in unusual locations or operating under unusual conditions. Some of these processes may also find their place in small plants.

The large iron producers are depending for their increased production on the additional iron which can be made in blast furnaces when ores with higher metallic and better sizing are charged, and also when oxygen is used.

Several years ago preliminary studies indicated that the use of oxygen in blast furnaces might not be economic, with perhaps the exception of furnaces in which ferro-manganese was smelted. Additional work in this field, largely pioneered by Weirton Steel, now indicates that the practice can be used to develop additional iron production as soon as the enormous amounts of oxygen required became available.

A forecast of future blast furnace operation was made by Julius Strassburger of National Steel Corp. National's prime objective is to obtain as much additional iron as possible from present blast furnaces in order to minimize the high capital cost needed for expansion with conventional blast furnaces, coke ovens, coal mines and such equipment. The goal is to obtain the optimum iron production with a minimum coke rate. As an example of the targets, the four Weirton Steel Co. furnaces which were operating not too long ago with a daily production of 5750 tons have as their ultimate target, some 7500 to 8000 tons of iron daily with the coke rate going down to 1300 to 1350 lb of coke per ton of iron. At Great Lakes, National expects to increase production from a recent 5200 tons per day up to 6600 tons.

These increases in production will be due to improvements which include the use of oxygen, improved iron ore, ore preparation, sintering, moisture in the blast, higher blast heats and improved coke quality.

Part of National Steel's program are two 12-ft sintering machines. The unit at Great Lakes has a length of about 200 ft and is rated at 8400 tons daily; the one at Weirton has a length of 147 ft and will be rated about 6000 tons a day. When these lines are finished, the National Steel plants will have complete facilities for crushing, screening, sizing and agglomerating the entire iron ore burden at each plant. They will use a burden consisting of 60 per cent sinter and 40 per cent sized ore. The sinter will contain about 10 per cent limestone, so that it will be partially self-fluxing, and it is hoped a completely self-fluxing sinter will be produced eventually. This use of lime in the sinter saves the heat needed for calcination of the limestone.

Weirton has been a pioneer in the use of oxygen to increase blast furnace production. They have tried additions up to four per cent oxygen with satisfactory results, the four per cent enrichment giving a 19 per cent increase in iron production. Therefore, Weirton is considering the installation of a second 500-ton oxygen plant to double their available oxygen supply.

The use of controlled moisture in the blast is known to give a smooth working furnace. The addition of moisture seems to become more essential to take full advantage of additional oxygen in the blast. Increasing oxygen requires an increasing amount of moisture, ranging from five grains per cu ft for one per cent oxygen enrichment, to 14 grains per cu ft for four per cent oxygen enrichment. When moisture is added to the blast, it has been found that a 30-degree F increase in blast heat is needed for each grain of moisture added.

Oxygen enrichment along with humidification of the blast gives increased carbon monoxide and hydrogen in the bosh gas and reduces the amount of nitrogen. This speeds up the furnace because reduction with hydrogen takes only one-fourth the time required by reduction with carbon monoxide.

As National Steel relines its furnaces, it is making a

Kaiser steel is adding a fourth blast furnace to the three already in production. This is one of the few new blast furnaces on the expansion program.

number of changes for improved operation which includes additional blast heating capacity to make it possible to maintain up to 30 grains of moisture for furnaces on oxygen, and perhaps 20 to 25 grains on furnaces with normal air blowing, Carbon-lined, water-cooled boshes are also to be installed to get cleaner bosh operation and perhaps larger furnace volume.

National Steel is also watching several of the direct reduction processes and is carrying out pilot plant work, hoping to find a charge material for the blast furnace in the form of a synthetic scrap or sponge iron.

A report by the British Iron and Steel Research Association, based on an electronic computer analysis of results of a six-year period from seven blast furnaces, shows an increase of 212 F in blast temperature will reduce the coke rate 40 lb per short ton of iron, as sinter is increased 10 per cent the coke rate will go down 70 lb per ton and increasing silicon one per cent gives a 120-lb increase per ton in the coke rate.

Second to the United States in the production of pig iron is Soviet Russia. Some reports made at meetings in the United States during the year indicate that, from the standpoint of production out of individual furnaces, the Russians may be setting records well ahead of American furnaces. It is reported that there are some 130 blast furnaces in the USSR. Production rates up to 2600 tons per day are reported for 26-ft units charged with rich, carefully prepared, ores, with high sinter charges and moisture control.

The world's largest single-unit oxygen producing plant for steel mill service started operation at the Duquesne works of the United States Steel Corp. This plant has a rated capacity of over 500 tons of oxygen per day. Some 90 per cent of this will be used to increase output and reduce fuel consumption in the ferromanganese furnaces at Duquesne. With the additional oxygen entering the furnaces, the normal daily production of 700 tons of ferromanganese is expected to be increased by more than 25 per cent, at the same time reducing coke consumption. The blast will have about six per cent oxygen enrichment. The oxygen fed to the ferromanganese furnaces is 95 per cent purity, but the remaining 10 per cent will have its purity increased to 99.5 per cent for use in electric furnaces, cutting and other applications.

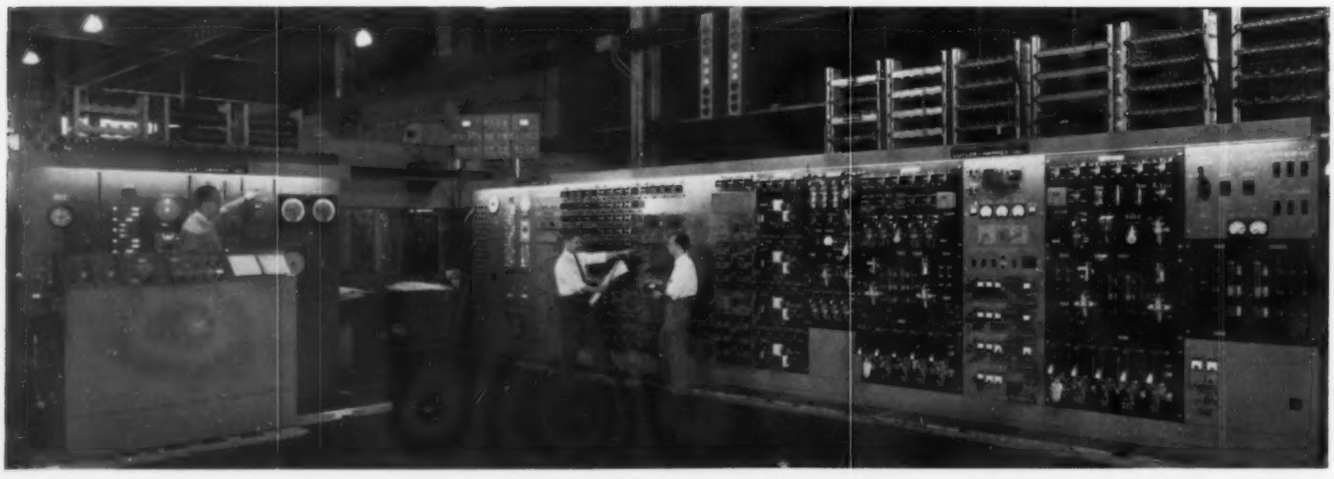
A new blast furnace at the Fairless works of U. S. Steel was christened on October 28. This third furnace increases the plant's ironmaking capacity by 50 per cent, as it is similar in size and construction to the original furnaces. The furnace has a 28-ft hearth diam and a 1600-ton daily capacity, and will increase ingot capacity of the plant because of the greater availability of hot metal. Auxiliary equipment installed includes a turboblower and a boiler, as well as a new ore bridge.

The automatic charging control on this new furnace gives greater flexibility in selection of charging program and conveys more information to the operating and maintenance personnel than has been done in the past. The complete system includes all the control equipment in the hoist house, stock house and cast house. The system was designed to keep maintenance cost and time at a minimum, and to maintain high production rates.

Extensive test runs on the use on controlled air distribution for a blast furnace have resulted in certain general conclusions as follows:

1. Tuyere performance is more uniform.
2. The tendency for heavy lime formations at the tuyeres has been minimized.
3. Inwall gas flow temperatures around the furnace periphery are more uniform, and therefore furnaces equipped with air proportioning are less subject to upset

New Fairless blast furnace has an automatic blast furnace charging control.



conditions. When it became necessary to take the systems off control, the furnaces reacted by going into spells of rough operation; the return to control had a settling effect. This shows that when the blast is not proportioned, the path of least resistance is followed, giving some degree of channeling.

Republic Steel Corp. will install a topping turbine for blast furnace blowing at its Cleveland plant. The unit will operate at steam pressures up to 850 psig at 850 F. The turbine, driving a 90,000-cfm blower and rated at 10,400 hp, will replace three reciprocating blowing engines.

The low-shaft blast furnace is meeting with more acceptance in Europe. An experimental unit has been in pilot plant operation since 1954 in Cologne. The pilot plant has produced all types of Bessemer, foundry and open hearth iron with normal compositions, except perhaps they had generally lower sulphur contents. Coal requirements have been about 4400 lb of coal per short ton of pig iron, but it is anticipated that in larger operating units, fuel requirements may go down to as low as 2100 to 2400 lb of coal per ton.

There is now under construction a unit which will be rated at 100 tons per day for the Klockner Mannstaedt-Werke at Troisdorf, near Bonn, Western Germany. The new low shaft furnace will use Minette ore from Lorraine with German and Swedish ore fines, and Ruhr gas coal.

Extensive experimentation with the use of wet Venturi scrubbing in conjunction with the oxygen-lancing of pig iron for desiliconization, carried out in England, indicates that the scrubber removed some 99.5 per cent of the fume. This overcomes one of the problems of the desiliconization process. A 20-min blow of some 30 tons of metal will evolve some 70 to 100 lb of fume. By increasing the flow velocities and water rates at the outlet, this concentration can be reduced to less than 0.1 grain per cu ft. Oxygen input in the tests was some 275 to 400 standard cfm.

A desulphurization process announced recently was developed at the Battelle Memorial Institute. This uses caustic soda and other sodium compounds to reduce sulphur content in either liquid iron or steel. Reports are that it will do this without damaging refractories or developing dangerous fumes. In addition to reducing the sulphur, the process reduces silicon, carbon and phosphorous through the addition of oxygen. Speed is a feature of the process, and silicon and sulphur contents can be lowered simultaneously, In test runs, sulphur was reduced from 0.10 below 0.02 per cent in a few minutes. With caustic soda, sulphur can go to less than 0.002 per cent.

In the process, hot metal is poured into one end of a reactor cylinder which is open at both ends. Heat is applied by a gas burner at the other end. The cylinder provides a large area at contact between the metal and the chemical reagent. As the cylinder rotates, centrifugal force separates gases, slags and metal in distinct layers. The heavier metal clings to the walls of the container, protecting refractory surfaces. The gas generated by the chemical reaction is carried off by an exhaust system. A low refractory shoulder on the inlet end of the cylinder permits movement of the liquid metal from one end to the other. As the liquid metal flows over the shoulder, it builds up a head which has sufficient force to carry it towards the exit. The result is a relatively thin layer of metal covering the inside surface and moving continuously toward the outlet end where it is collected.

Rate of travel depends on the head built up at the inlet, and this in turn is controlled by the rate at which the molten metal is poured into the container. Important advantages claimed are constant mixing under pressure, large area of contact between liquid metal and chemical reagents, plenty of heat available to produce required reaction rates, simultaneous separation according to specific gravities, operation in parallel or in series with present equipment, high production rates and low investment and operating cost.

It has been estimated that some $9,000,000 to $12,000,000 is being spent per year by American companies in research on the direct reduction of ore. In 1957, some five to six methods were discussed quite widely. These include the R-N process, the Dwight-Lloyd-McWane process, the Cyclosteel process, the H-iron process, the Madaras process, the Esso-Little process, the Diamond Alkali process and U. S. Steel's Nu-iron process. Practically every major steel company has a pilot plant in operation or production.

One of the processes which may be closest to production operation is the R-N process pioneered by Republic Steel Corp. and National Lead Co. Republic has had in operation for two years at their Spauling mine, near Birmingham, a rotary kiln which can handle some 135 tons of ore a day. In the operation, ore and coal fines are charged in at one end of the kiln. The ore is a concentrate; the coal fines are a carbon char produced from low grade non-coking coal or coke breeze. The amount of carbon used is several times that needed to reduce the ore. The kiln is fired with an oxidizing flame, but with the excess carbon the reducing conditions are sufficient to give up to 90 per cent reduction. The end product is quenched in water and crushed. The uncombined carbon is returned to the kiln, and the metallic iron is separated from the gangue and put through a briquetting machine. Republic reports that the briquets have an iron content of 95 per cent, and can be used as No. 1 scrap in the open hearth and electric furnaces. Another grade of the material with a lower iron content can be used for blast furnace charging.

One electric smelting process which seems to offer promise is the Dwight-Lloyd-McWane process, in which ore, coal and moisture are put in a pelletizing drum. Coal fines are also included in excess of the carbon needed for reduction. These pellets are then spread on a sintering strand and ignited. The air is drawn through the pellet bed, and the blast continued until about six per cent carbon by weight remains in the charge. At this time the oxides are reduced some 40 per cent and the carbon changes to graphite which binds the pellets together. The partially reduced pellets are then charged to an electric smelter. By adding coke and flux as needed, the reduction is completed to molten pig which is suitable for open hearth charging.

The Cyclosteel process combines both reducing and oxidizing reactions, and can go directly from ore to steel. Ore is put first in a prereducer into which hot gases are fed. The hot partially reduced ore then goes into a vertical cyclone drum, where the ore is reduced by a mixture of coke, coal or fuel gas, and oxygen. The reaction time is very fast. Further down in the vessel

oxygen is introduced. This involves the use of a controlled reaction, since theoretically reduction and oxidation in the furnace can be controlled by varying the partial pressure of oxygen entering the furnace, and this can be set so as to produce steel of predetermined analysis. At the bottom, molten steel and slag are obtained.

The process requires appreciable oxygen. The reactor also has to be water-cooled. An advantage is that ore fines can be used. It is believed that the process will be able to produce a steel free of phosphorous. Current experiments have been limited to ores with low sulphur content. There have been troubles with refractory erosion.

The H-iron process, described in last year's development story, received a big boost this year when Alan Wood Steel Co. announced that they will build a $3,600,000-plant using the process to make iron powder.

Among the advantages of the process are reduction temperatures well below the point where the reduced iron powder becomes tacky, thus avoiding bed sticking and loss of mobility. The high pressure used (up to 400 psig) increases the speed of reaction. H-iron has been used in tests in both open hearth and electric furnace heats with excellent results.

A number of commercial H-iron installations have been completely engineered. Estimates indicate that at an east coast plant, with a fuel oil costing $3.08 per barrel, H-iron could be made at $13.32 per ton of iron above ore cost in a plant producing 2200 tons per day. In the case of a plant in the Texas area where natural gas is present, the manufacturing cost of the H-iron above the cost of the ore is $6.13 per ton.

The H-iron cycle retains one disadvantage common to low-temperature direct reduction processes. It will not remove any contaminant except oxygen. Ore that is high in silica and phosphorous will yield iron also high in these impurities.

In the Madaras direct reduction process, the ore is laid down in a bed, minus coke and limestone. Hot hydrogen gas and carbon monoxide at 1600 to 1900 F are pumped through it, melting out the iron. Reducing gas is made externally by reforming natural gas. The Madaras process is working successfully in a small plant in Monterey, Mexico. Steelmaking tests on the iron smelted by this process have been made by several American steel plants.

The Esso-Little process uses an approach which has been developed in catalytic cracking of petroleum and the fluid bed techniques. This process is based upon the partial combustion of natural gas with air to carbon monoxide and hydrogen. The air is preheated to between 1500 to 1600 F, and the natural gas from 600 to 700 F. Ore is first fed to a fluidized bed for preheating to 1500 to 1600 F. The preheated ore passes by gravity to a reducing reactor where it proceeds downward through two or three reducing fluidized bed stages, contacting the hot reducing gas.

The off-gas is used to preheat the ore, air and natural gas, and to provide fuel for boilers. The reduced ore goes to an ore cooler, where it contacts cooled off-gas. The cool reduced particles may then be agglomerated by briquetting or by running them through pinch rolls. The process differs from the U. S. Steel and H-iron process in that there is no recirculation of the reducing gas. To attain efficient gas utilization, it is necessary to

The new nitrogen plant near Provo, Utah, U. S. Steel Corp., Columbia-Geneva Steel Div., is indicative of the greater emphasis being placed on production of chemicals by the coke plants.

operate at temperatures where reaction rates are fast and to employ multiple stages of reduction.

Not too much has been said about the new iron process of U. S. Steel. It is understood, however, that it involves the use of a fluidized bed, and uses hydrogen and carbon monoxide as a reducing agent, giving an iron powder as the product. It is a continuous process and the reducing gases are obtained from natural gas.

High grade iron ore fines (under ¼ in.) are introduced on a continuous basis to the preheater where the temperature is raised to 700 F by the sensible heat in the gas coming from the subsequent reducing reactors. The preheated ore then passes to an ore heater where the temperature is raised to 1700 F by combustion of natural gas or other suitable fuel. The ore then goes into a reducing reactor where the temperature is kept at about 1300 F. There the ore is reduced to FeO. The sensible heat in the ore supplies part of the heat needed for the reducing reactions. The partially reduced ore then goes into a second fluid bed reactor and the FeO is reduced to metallic iron. The reducing gas consists of carbon monoxide and hydrogen produced by reforming steam and methane. It is reported that moderate pressures of 60 psi are used to give greater utilization of the reducing gases.

A patent issued during the year describes a process for the production of metallic iron or pig iron by the reduction of iron ore in lump form with carbon monoxide and hydrogen. In this process, the use of coke is partially or entirely eliminated, depending on operating conditions.

The equipment consists of a vertical shaft which is charged at the top with iron ore and limestone. The molten iron and slag are tapped off the bottom of the shaft. Reducing gas is generated in a gas generator and the mixture of carbon monoxide and hydrogen is passed at about 2600 F to the lower portion of the shaft, where the iron oxide is reduced to metallic iron and the carbon monoxide is oxidized to carbon dioxide. The hydrogen forms water with the oxygen. Some of the gases are vented from the top of the furnace and are used to generate steam. In addition, a short distance below the top of the furnace, oxygen is introduced to

burn the unreacted carbon monoxide and hydrogen. This burning preheats the incoming charge of iron ore and limestone. At another intermediate point as much as 70 per cent of the gas is recirculated back to the gas generator.

Summarizing, the direct reduction of high grade iron ores is definitely feasible from a technical standpoint, but geographic and economical factors will probably dictate plant locations. In cases where iron is the by-product of some other process, they may also be economical. One of the attractive features of direct-reduction plants is that they can be built in small units compared with the blast furnace plants. This might be of advantage to smaller integrated producers.

Research done on blast furnace coke properties indicate that certain cokes, even though they indicate excellent operating results in conventional tests at normal room temperatures, may not work properly at the higher temperatures in the critical tuyere zone. As a result, a high temperature compression test has been developed which simulates conditions encountered by the burden in the high temperature zone of the blast furnace, and apparently predicts quite satisfactorily the relative performance characteristics of a given coke.

Jones & Laughlin Steel Corp. announced that it was producing benzene, toluene, and xylene at higher purity than heretofore available, as a result of a new plant just completed. This plant substitutes hydrogenation for the conventional acid washing step, eliminating a source of high maintenance cost and increasing the amount of product recovered.

The operation of coke plants are leading steel plant men further into the chemical field. An example of this was the initiation of operations of the nitrogen plant at U. S. Steel's Columbia-Geneva works at Provo, Utah. This installation uses several Montecatini processes for the manufacture of anhydrous ammonia and for producing other nitrogen products from coke oven gas. Hydrogen is extracted from the coke oven gas and mixed with nitrogen separated from the air to produce anhydrous ammonia by a synthesis process. Some of the ammonia production is also further refined into nitric acid. By mixing the anhydrous ammonia with nitric acid, ammonium nitrate, a high strength fertilizer, also can be produced.

In this process, the coke oven gas goes to the nitrogen plant from the coal chemicals recovery plant where it has been completely stripped of constituents such as benzene, toluene, xylene, naphthalene, etc. The gas is compressed at about 190 psi, then goes through a series of washing and absorption columns in which aqueous ammonia, water and caustics are used to remove such impurities as carbon dioxide and hydrogen sulphide. The washing liquids are subsequently processed to recover ammonia and acid gases, and the former is reused in coke oven gas purification.

The acid gases are sent to another section for the manufacture of sulphuric acid, a secondary product of the new Geneva plant.

The partially purified coke oven gas enters the precooling and hydrogen separation section where it is cooled through the use of heat exchangers and an ammonia refrigerant. It is stripped of contained gums by solvent washing and piped to a cold box. In the cold box, the temperature of the gas is further reduced. Then, in a complex array of heat exchangers, separators and washers, gas products such as methane, ethylene and others are removed, leaving only hydrogen for combination with the nitrogen in the production of ammonia.

The union of the nitrogen and the hydrogen is done in an ammonia synthesis converter. Under controlled conditions of pressure and temperature in the presence of a catalyst, the nitrogen combines with the hydrogen to form a gaseous ammonia, which is then condensed and stored as a liquid at low pressures.

Under construction at the Clairton plant of the U. S. Steel is a unit for refining light oil. One of the aims and designs of this plant is to eliminate the impurities such as thiophenes down to one ppm from the 200 to 500 ppm in the usual plant. It is also hoped to reduce xylene from a maximum of four per cent down to less than ½ per cent. This construction is typical of that demanded by coke plant operators in their newer units, since operators now require more efficient washing of gases, thiophene and paraffin-free products, recovery of ammonia in the form of ammonium phosphate, elimination of odor, etc.

Another interesting development is a new continuous removal process for phenol, using a counter-flow centrifugal extractor. It is reported to remove up to 95 per cent of the phenol from the plant waste liquors, using smaller quantities of caustic soda. It produces a sodium phenolate solution of 35 to 40 per cent strength without the use of concentrating steam.

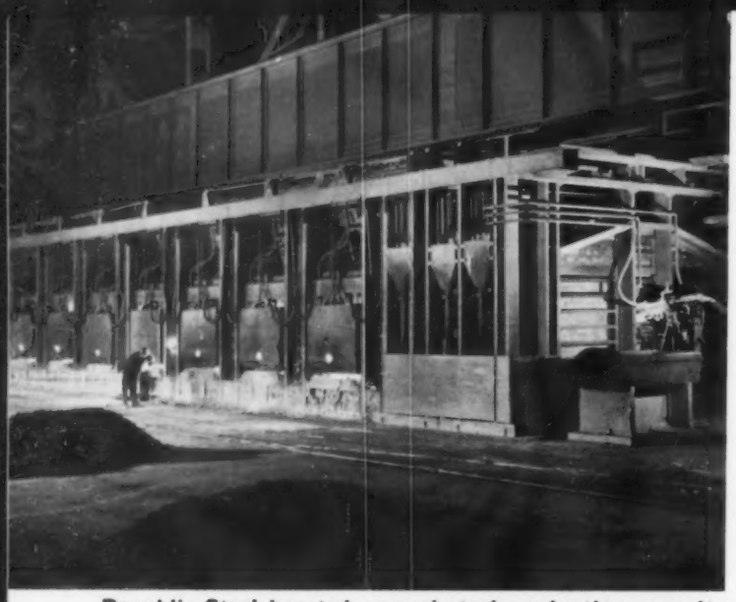
STEELMAKING

There were a number of important developments in steelmaking in 1957. The outstanding one was the progress made on making steel in the top-blown oxygen converter. Initial reports from J & L's Aliquippa plant which started late in the year indicate great possibilities. Other steelmakers are awaiting further results with great interest. The slackening in demand for steel will hold some operators back for awhile, but as soon as the market picks up and the patent situation clarifies, a number of other units will undoubtedly be authorized.

The making of steel in the open hearth or a modification of the open hearth without fuel also offers other possibilities for further development.

The steel and chemical industries burn up large amounts of oxygen. In 1957, some 54,000,000,000 cu ft were produced and some 60,000,000,000 cu ft are expected to be used in 1958. The steel and metalworking industries use about 75 per cent of all the high purity oxygen that is made. In 1957, for every ingot ton of steel made, some 200 cu ft of oxygen were used.

Oxygen usage is usually limited by the available supply and the trend in steel plants is toward developing an adequate supply. No definite pattern has yet been established as to which type of supply is the most economical, and apparently it varies with local conditions. A number of the plants have installed their own oxygen units. In other cases, plants are purchasing their oxygen from commercial sources located outside the steel plant limits but connected by direct piping. In some cases, an oxygen plant is built by the supplier on the steel plant premises and leased to the steel plant.



Republic Steel boosted annual steel production capacity at Cleveland 788,000 tons by the construction of two new open hearth steelmaking furnaces and enlargement of four others.

In a report given before the 1957 AISE Annual Convention, some rather interesting economic studies on this were given. For example, Inland Steel estimated that a 200-ton per day plant, with a consumption of 4500 tons per month, would show costs of $14.91 per ton for a mill-operated system, and $18.89 per ton for a system operated by a supplier. When the consumption was reduced to 3000 tons per month, cost was estimated at $20.33 per ton for a mill-operated system, and $26.09 per ton for a system operated by a supplier. In spite of this, it was decided to purchase the oxygen, since the cost of building a 200-ton plant was estimated at $2,000,000 and a return on the investment of only 5 to 5.2 per cent was indicated. Inland decided to run an 8-in. pipeline to a supplier 2½ miles away. In addition to financial considerations, the setup assures a supply for peak periods. Inland also came to the same conclusion on high-purity oxygen.

Jones & Laughlin Steel Corp. adopted another arrangement. They had a plant built on a lease arrangement under which they will pay a lease fee for 15 years. At the end of that time, they will take over the plant. They estimate that, on the basis of a 100-ton plant, the oxygen cost figures vary from 87¢ per 1000 cu ft or $20.90 a ton when the plant is being operated at a 100 per cent rate to $1.46 per 1000 cu ft or $35.00 a ton with a 50 per cent ingot rate. These figures are the operating costs including lease charges, which at the end of 15 years should take a sharp reduction.

In the last 12 years, the use of oxygen in steelmaking has increased in a very marked degree. At the present time the following summarizes usage in various steel mill operations:

1. Open hearth lancing—150 to 300 cu ft per ton of ingots.
2. Open hearth jets through roof—100 to 500 cu ft per ton of ingots.
3. Open hearth combustion—125 to 500 cu ft per ton of ingots.
4. Bessemer—400 to 500 cu ft of oxygen per ton of ingots.
5. Top blown oxygen converter—1800 to 2200 cu ft per ton of ingots.
6. Hot scarfers—100 to 150 cu ft per ton of slabs.
7. Blast furnaces—1200 to 1500 cu ft per ton of pig iron at one to four per cent enrichment.

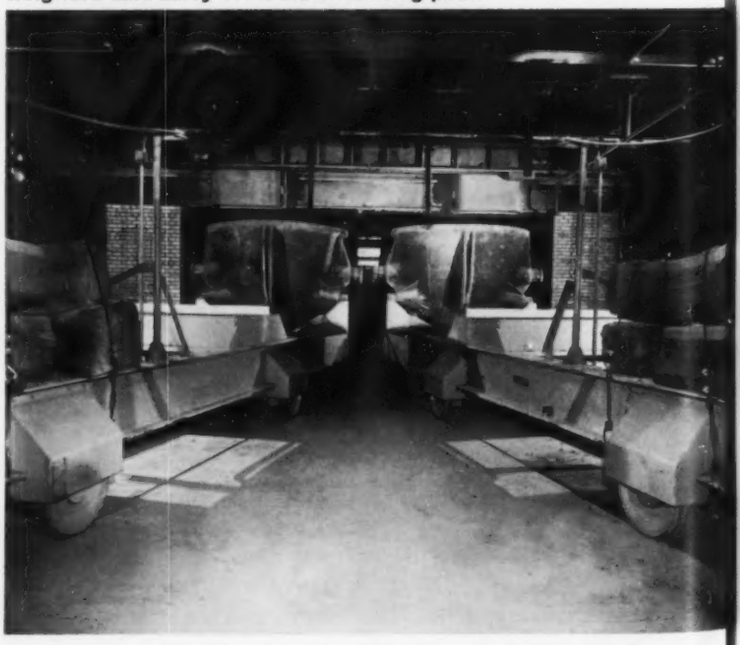
Although oxygen has for some years played an important part in increasing productivity in open hearth furnaces, at levels above 0.25 per cent carbon in the bath, the violent splashing of the slag has been hard on the refractories. The Steel Company of Wales, however, is injecting oxygen, using about 500 cu ft per ton, through a water-cooled lance extending vertically downward from the crown of the roof, without any particular damage to the refractories.

An American company is the licensee for this process. The Steel Company of Wales reports that this method has advantages over introducing the oxygen through the back wall or charging doors. The mechanism is simpler, there is no large steel framework projecting over the back platform, and there is no interference at the front of the furnace. By locating the lance in the center of the hearth, there is half the length of the bath available to burn the combustible gases produced from the oxygen reaction.

The introduction of oxygen may be started at relatively high carbon levels—up to about 0.45 per cent—at rates up to about 40,000 cfhr. As the carbon drops, the oxygen is increased to about 60,000 cfhr. The rate of eliminating carbon is increased about 20 per cent, and the refining time from a given carbon to tapping is cut by more than one-half. The data indicate the higher the carbon content at which oxygen blowing is started, the greater is the gain. However, above 0.45 per cent carbon, the reaction is too violent for practical use.

One expansion program which is being watched with keen interest by the steel industry is that of Acme Steel Co. at Riverdale, Ill. The reason for the interest is the $51 per ton of annual ingot capacity which the company estimates the plant will cost. This plant includes two hot blast cupolas which will produce 1200 tons per day of molten iron from pig iron, scrap,

Two specially designed slag cars handle front flushing of Weirton Steel's 600-ton open hearth furnace. The counterweighted cars carry 11-ft diameter slag pots.



limestone and coke; two 50-ton oxygen converters for producing steel; a 110-ton per day oxygen plant; soaking pits; blooming and billet mill. The combination of cupolas with converters is new in the United States. The plant, scheduled for completion early in 1959, will have an annual capacity set for 450,000 ingot tons. The total project is estimated at $23,000,000.

Some open hearth capacity was added during the year, principally as individual furnaces in existing shops. Detroit Steel Corp. completed a new 275-ton open hearth furnace at their Portsmouth, Ohio, plant. This furnace has two-pass checkers arranged to permit lancing for the full depth of the settings in both passes. This was accomplished by extending charging floor posts to the lower pad level throughout the building, thus providing access to both sides of all regenerators.

The Colorado Fuel & Iron Corp. also started a new 230-ton open hearth furnace during the year, using flat suspended checker chamber roofs.

The 600-ton furnace which Weirton put into production in December, 1956, has been a successful consistent producer. The main roof of this furnace is entirely sprung, and the roofs over the slag pockets, fantails and regenerators are suspended. The furnace is of silica brick except for zebra construction along the back wall. Furnace reversal is automatic and can be initiated by time, temperature difference or maximum temperature.

The high price of scrap, combined with a plentiful iron supply, changed the scrap-iron ratio used in the open hearth furnaces. For the industry as a whole, the 1956 ratio averaged about 52 per cent scrap to 48 per cent iron. In 1957 this ratio gradually changed and toward the end of the year was running 47 per cent scrap to 53 per cent iron. This is the usual swing toward the cheaper material which occurs whenever the demand permits a choice—a swing which further lessens the demand for scrap and brings lower scrap prices.

Inland Steel Co. has made steel in the open hearth with no fuel but with oxygen blowing. The dampers are opened to let the waste gases escape through both checkers, and oxygen is blown in at the slag metal interface by lances inserted through three doors. Heat time for 125-ton heats average 3.39 hr. These experiments indicate that the bessemer type vessel is not necessarily the only equipment in which a steel can be made pneumatically.

Inland's tests showed that high carbon, low phosphorous steel can be made from pig iron containing 0.7 per cent or more phosphorous without external heat. The steel produced is identical with basic open hearth steel. Some initial work done was in an 800-lb side-blown converter, which made 750-lb heats. From this preliminary work, it was decided to run full-scale tests, and four 125-ton heats were made in a modified 175-ton open hearth furnace.

A few minor modifications were made on the furnace such as dropping the level of the flush hole to accommodate the 125-ton heat size, and enlarging the flush hole to permit rapid slag runoff. A second hole was put in each of the three middle doors, above the existing hole, to permit the simultaneous introduction of three oxygen lances.

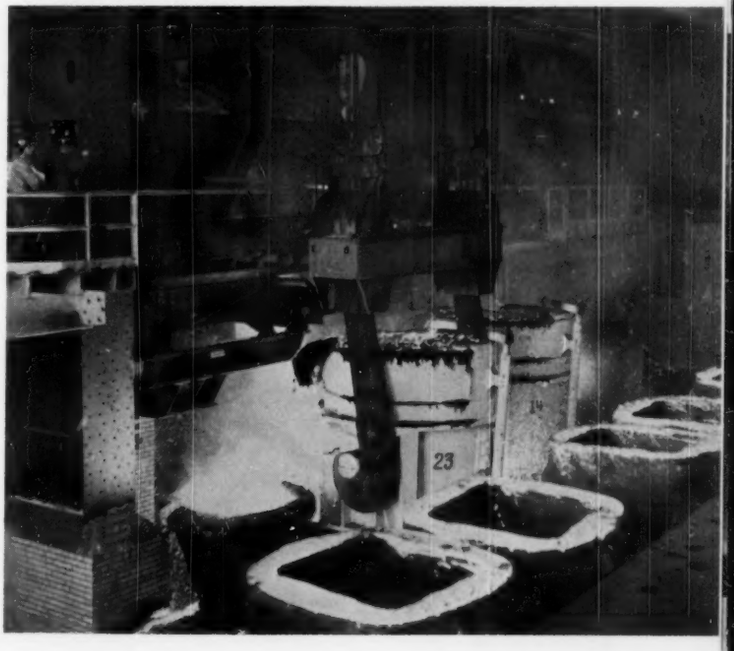
Experimental procedure was to bring the furnace up to the slagging temperatures, which could be expected after tapping a heat. The tap hole was closed and fuel turned off. Dampers were opened to remove waste gases. First, a cold charge was introduced consisting of limestone, ore, burnt lime and finally scrap. The hot metal addition was poured on top of the cold charge, and lancing was begun with 95 per cent oxygen introduced essentially at the slag-metal interface at the highest possible flow rate. A slag developed rapidly when oxygen lancing was begun and the heats began to flush a short time later. One of the objectives was to find the minimum oxygen blowing rate which would not require fuel, and this was found to be about 1980 cfm.

Extensive tests covering over 800 open hearth heats show the energy from a jet reaction flame can successfully atomize liquid fuels in the open hearth. The method is both practical and economical. Compared with standard steam atomization, jet atomization increases steel production up to 12 per cent and lowers fuel consumption (up to 10 per cent), with up to 30 per cent higher firing rates.

The jet-burner uses a hot gaseous flame at high velocity to atomize and preheat the main liquid fuel before burning. The hot gases and energy of the jet are obtained by burning a small amount of gaseous or liquid fuel with air or oxygen under pressure in a specially designed combustion chamber located in the rear of the burner. Atomization of the main liquid fuel is then accomplished by injecting the liquid fuel directly into the hot gas stream. Temperature ranges from 3000 to 4000 F, and the velocity runs between 1000 and 1500 fps. As a result, there is a faster burning flame, higher temperature and increased thermal radiation to the bath.

Armco Steel Corp. is trying out an unconventional open hearth charging system at their Butler plant. Scrap is brought directly on to the open hearth floor in gondola cars and transferred by magnet to a charging hopper. Three charging pans are under the hopper, one of which receives the charge, and the other two

First heat of steel is tapped from new open hearth furnace at Pueblo plant of The Colorado Fuel & Iron Corp.



take any spillage which may occur. As soon as the pan is full, the charging machine moves it directly into the furnace. The system eliminates the string of buggies which block one furnace when another is charging. It is estimated that it speeds up charging by 15 per cent.

A new method of adding aluminum in the manufacture of aluminum-killed steel uses a special aluminum bar which is wired into place in the mold before the steel is poured. It is said to result in more uniform absorption of the aluminum and complete usage of the bar, with a cleaner ingot and higher yield. It is also claimed that the consumption of aluminum can be reduced because most of the aluminum melts below the surface of the steel.

Definite possibilities for better open hearth operation may lie in the use of magnesite-chrome basic electrocast refractory. This material is manufactured by electrically melting the raw materials at temperatures up to 4300 F and casting the molten refractory into molds. It has been used in electric arc furnaces at the slag line and in other hot spots, and in open hearth furnaces in the roof, skews, front wall piers, downtakes, end-walls and back walls. The cost of the brick itself is about ten times greater than that of conventional basic brick, although the cost proportion of the refractory in place is not that high.

Republic Steel has used the material in a number of roofs, at first in zebra-type construction. After a number of various designs, a furnace roof was constructed entirely of electrocast from end to end. It included 16½-in. wearing strips front and back for a distance of 30 in. from the skew backs, with rib rings 16 x 6 x 6 in., and 13½ x 6 x 6-in. alternate rings. No wear was noticed until 60 heats were on. It was finally rebuilt after 555 heats and four shutdowns for repairs. Cost of this rebuild was $3000 higher than previous rebuilds. It was estimated that if this roof obtained 388 heats without needing repairs, it would be economical from a delay and increased tonnage standpoint, since it will stand higher firing rates with a resulting two to three more tons per hour.

A new refractory gunning system is especially designed for tap hole repairs and hot repair of basic open hearths, banks or bottoms. No batch mixing is required with this equipment. The mix is fed continuously into the system through two hoppers which supply the unit's main reservoir. Water is automatically mixed into the material and the system shoots the mixed material at 40 psi at rates of 200 lb per min without pulsation or interruption. The unit is designed to use a mix made from refractory periclose grains with about 95 per cent magnesium oxide. The mix bonds into a crystalline mass at a relatively low temperature.

One steel producer reported improved pouring operations by using chemically capped steel. Chemically capped rimming ingots minimize the segregation that sometimes makes steel from the top part of the ingot difficult to draw. Scrap is reduced from 7.8 to 1.8 per cent. The technique has its maximum advantages when used in low carbon ranges. In heats above 10 points of carbon, the results are erratic.

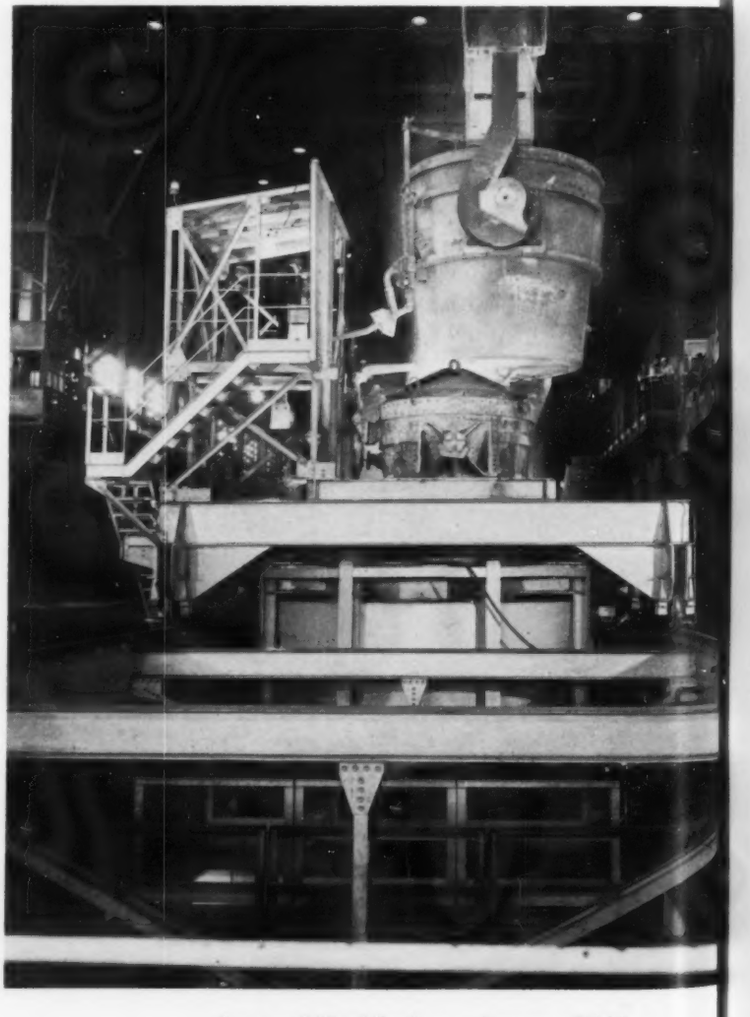
Casting steel ingots free from imperfections is accomplished through the use of a 0.040-in. thick liner of glass fibers in the mold. The liner prevents splashes from striking the mold wall and forming surface imperfections on the ingot. The fiberglass melts away at the contact surface.

A new kind of hot top is in use in Sweden, made from sand or crushed slag which is wetted with sodium silicate. The mixture is then formed in the mold by use of a simple collapsible tool. The mass is hardened with carbon dioxide, the tool is collapsed and lifted out. It is stated that the top can be made for almost any mold size in less than 8 min.

Another hot top developed in Sweden consists of rectangular cakes of crushed coke, or a mixture of sawdust and crushed coke with a sulphite cooking liquor as a binder. After being dried, the cakes are coated on the inside face and lower edge with a refractory material such as a mixture of iron oxide and powdered aluminum or fine sand. This material generates heat when it comes in contact with the molten steel. No preheating is necessary. As the molten steel comes in contact with the coating on the cakes, the coating material sinters, forming a glaze which keeps the carbon and sulphur in the cakes from going into solution in the steel. When the material in the cakes is heated to the ignition point, it bursts into flame. Since the material in the dried cakes is porous, the pores reduce heat transfer, and provide a means for evolved gases to escape without going into the molten steel.

The top-blown oxygen converter process is meeting

Vacuum castings give better ingots for forgings at U. S. Steel's Duquesne Works.



with greater acceptance in the United States and throughout the world. At the present time, units in operation or authorized include two 40-ton units at Dominion Foundries and Steel, Ltd., Hamilton, Canada; three 40-ton units at McLouth Steel Corp., Trenton, Mich.; two 65-ton units at Jones & Laughlin Steel Corp. at Aliquippa, Pa.; three 65-ton units at Kaiser Steel Corp. at Fontana, Calif.; and one 60-ton unit at Algoma Steel Co., Sault Ste. Marie, Canada. In addition, there are 22 units scattered in foreign plants ranging from 20 up to 66 tons. It is estimated that total production of all these plants, both within and without the United States, will exceed 7,000,000 tons in 1958. McLouth Steel Corp. also recently ordered two 80-ton oxygen steel converters and auxiliary equipment for their expansion program at their plant in Trenton.

To prevent air pollution by the oxygen converters, the J & L installation has a movable water-cooled hood to collect waste gases, a spark box with a water spray, a duct system with water-cooled dampers, an electrostatic precipitator, an induced draft fan and a stack.

The hood is approximately 20 ft high with an open area of 12 ft square and is water jacketed to provide cooling. During a campaign, the hood is rolled in place over the furnace and attached to the water cooling system and spark box. The annular space between hood and furnace mouth allows infiltration of air to burn the furnace gas. The hood and inlet to the spark box provide a combustion chamber for burning the carbon monoxide to carbon dioxide.

The spark box serves as a spray chamber to cool, condition and mix the gas and water vapor before they enter the precipitator. It also collects large dust particles. Unevaporated water forms a slurry with coarse dust particles. After the slurry is flushed into a sump in the scrap aisle, it is removed by a grab bucket. The duct system between the spark box and the precipitator is insulated externally to prevent condensation inside the duct and conserve heat between blowing periods. Two perforated distribution plates are located in front of the precipitator to give proper gas distribution. Some 238,000 cfm of gas are cleaned with an efficiency of 99.5 per cent.

The precipitator is of the horizontal flow plate type. It has two units, each with three 9-ft sections. Collecting plates are kept clean by continuously operated, automatically controlled magnetic impulse rappers. Discharge electrodes are kept clean by high tension vibrators on top of insulator compartment.

Jones & Laughlin also has installed at Aliquippa a traveling hood car system which is used to collect fumes from leaded steel ingots. The car motion is linked to a ladle crane. The systems are used in both the bessemer and open hearth departments, but since only one department pours leaded steel at any one time, a 33-in. diam switch valve is used to connect the exhaust flow from the active area.

The rotating oxygen converter process reported last year is meeting with some favor. Test runs are under way at the original installation with low phosphorus American-type ores.

An 80-ton rotating converter is being built at Oxelosund, at a new steel plant on the central coast of Sweden. It is the first of two to be installed at a new plant which will have an ultimate capacity of 475,000 tons per year.

A major French steel producer, the Societe Lorraine de Laminage Continu (Sollac) has been licensed to construct a 100-ton rotating converter. The product is expected to be used for automotive body sheet. This is the first firm outside of Sweden to be licensed to use the Stora Kal-Do process.

Another rotary steelmaking process is under development at Huttenwerk Oberhausen in Germany. The unit here consists of a horizontal cylindrical rotary vessel which has enough capacity to take the whole tap (about 60 tons) of an adjacent blast furnace. The vessel has an over-all length of approximately 48 ft, an inside diameter of 8 ft-9 in. and an outside diameter of about 12 ft. There are openings in the inwalls, one at the front for charging and for injecting the oxygen lance. An opening in the rear is used for tapping, removal of waste gases and flushing of the slag. The speed of rotation varies, running between 0.1 and 0.5 rpm. The lining of the unit consists of a tar dolomite layer rammed over a permanent magnesite lining. This rotary unit is used for prerefining pig iron, for making steel from low phosphorous iron, and making steel from high phosphorous iron.

In prerefining pig iron, the tap from the blast furnace is put into the unit and blown for about 40 min with oxygen. Then a major part of the slag is removed and a one per cent carbon prerefined basic iron is tapped into a transfer ladle for use in the open hearth.

When refining low phosphorous pig iron to finished steel, the process is similar to that of prerefining pig iron except that the process is completed when the required carbon content is reached. In the event the original iron is high in phosphorous, a double slag process is used. It has been estimated that the cost per annual ton of this material in Germany is about two-thirds that for a typical open hearth installation.

In addition to the 60-ton unit already in operation at Oberhausen, a 100-ton unit is under construction. It is also reported that the South African Iron and Steel Industrial Corp. will install rotary steelmaking units at its Vanderbijl Park and Pretoria works to increase ingot capacity by some 600,000 tons annually. The rotors will be 50 ft in length, 15 ft in diam and will handle 100-ton heats.

A simplified technique for spectrochemical determination of elements in samples of unknown origin and basic composition was developed at U. S. Steel's research center. This procedure, known as the carbon-matrix technique, uses a graphite electrode to create the necessary dilution, and a known small amount of germanium to produce a reference intensity in the spectrum. Another spectrochemical method for analyzing alloys which speeds up results is a direct reading instrument which gives an instantaneous recording spectograph. Average time to complete an analysis under routine conditions is about 1½ min. Unit was developed in France.

A recent survey showed that facilities for vacuum melting in the United States at the end of 1957 totaled about 20,000,000 lb by induction vacuum melting, and 50,000,000 lb by consumable electrode vacuum arc melting. When present planned projects are completed

by the end of 1958, these figures will increase to 27,000,000 and 100,000,000 lb, respectively. Both processes improve mechanical properties and eliminate gases, giving very high purity melts.

Induction melting has the advantage of affording close control of composition. It does not remedy solidification and segregation, and it is the more expensive of the two processes. On the other hand the consumable electrode vacuum arc melting process eliminates or minimizes segregation, gives homogeneous mechanical properties and is lower in cost than induction vacuum melting. The extent of which each method is used will depend on the properties required of the product.

Allegheny Ludlum Steel Corp. put into operation at its Watervliet, N. Y., plant what is probably the world's largest furnace for melting high-purity superalloys under vacuum. This unit uses the consumable electrode remelting process and is capable of producing 26-in. diam ingots weighing up to 12,000 lb. Commercial availability of the large ingots will enable the superalloys to be used in many commercial applications previously not feasible. The new furnace brings Allegheny Ludlum's capacity for producing these special alloys to 2,000,000 lb monthly.

Several units are now in operation for vacuum stream degassing. In one plant of a major steel producer, a 10 to 12-ton unit has been in service for the better part of a year to obtain operating data and a 250-ton unit went into operation in the summer of 1957. Improvements which have been obtained from the operation are as follows:

1. Hydrogen content is reduced to as low as one ppm.
2. Ingot segregation is greatly reduced.
3. Oxygen content is reduced up to 35 per cent.
4. Nitrogen content is reduced by as much as 15 per cent.
5. Ductility of the steel is increased at least two per cent.

Estimated cost for operating and maintaining stream degassing equipment and amortizing the capital outlay adds $6 to $9 per ton to the price of the steel. Other estimates for the premium costs are that vacuum stream degassing will run about one cent a lb, compared with about 40¢ a lb for induction melting and 20¢ a lb for consumable-electrode melting.

It is reported that vacuum stream degassing capacity by middle 1958 will be 10,000 tons per month. At the end of 1957, it totaled about 3000 tons per month.

Several reports were given during the year on the present status of large tonnage continuous casting plants discussing mainly the results of the work done at Inland Steel Co. who were considering the installation of a large continuous casting plant for producing slabs.

Some of the conclusions on limitations are:

1. Maximum machine speed—35 in. per min.
2. Maximum slab width—40 in.
3. Maximum slab thickness—6½ in.
4. Maximum casting rate—70 tons per hr for killed or semi-killed steel and somewhat less for (rimming) steel.
5. Maximum machine availability—50 per cent, based on one-hour casting.

New blooming mill installed by Jones & Laughlin at the Cleveland plant, at a cost of about $17,000,000, went into operation in November.

6. Maximum metal availability from ten-furnace section of an open hearth shop 60 per cent.
7. Annual capacity 180,000 tons, based on 50 per cent machine availability and 60 per cent metal availability.

An evaluation of the advantages of continuous casting compared to a blooming mill follows:

1. Apparently lower capital and operating cost.
2. Fewer personnel required.
3. Less plant area required.
4. Greater productivity for the given metal supply.
5. Reduction of processing time.
6. Reduction of in-process inventory.

The disadvantages seem to be:

1. Vertical height requires pit or high molten metal lift.
2. Multiple units are required for large heats.
3. Untried and undeveloped for large tonnage operations.

The United States has been slow in adopting continuous casting. Of the three units which have been installed in the United States, only the one at the Babcock & Wilcox Co. is in commercial production. Of the other two, one is believed being used only for experimental purposes, and the other is apparently idle. Atlas Steels in Canada has one unit in commercial operation. It is also reported that there are five units in operation in Great Britain (of which one is commercial), seven commercial units in France, and eight units in West Germany of which four are commercial. In Russia, it is reported there are six continuous casting machines of which five are commercial and one is a pilot plant.

Casting speeds range from 10 to 240 in. per min, and production runs from 1½ up to 94 tons per hr. Practi-

cally all types of stainless and alloy steels are being made on these various continuous casting units. In one plant, gray iron is being continuously cast. Shapes also vary widely. Among the larger are slabs cast at Atlas Steels which run to about 6½ x 24 in. One unit in Russia is casting 8 x 24-in. slabs.

A pneumatic level indicator has been developed by the British Iron and Steel Research Association for the continuous casting process which can indicate the level of the liquid to an accuracy of ½ in. over a height of 6 in. The signal obtained from this indicator can be used to maintain pouring to give constant level in the mold.

ROLLING

Progress in the rolling field was usually with the objective of speeding up operations or making them more automatic. In turn, application of automatic operation was often done to speed up operations by replacing relatively slow human reactions with faster machine or electrical movements.

A number of primary and roughing mill operations are having automatic control systems applied; other applications are in use in hot strip, structural and tinplate mills. At least ten plants will soon have reversing mills controlled by punch card systems, and a tandem cold mill is partially controlled by punch cards. One of the chief incentives for the use of such controls is to improve quality. A second incentive is to get more production out of the mills by minimizing waste and non-productive time that the metal is not in the mill.

As an example of the benefits to be obtained, the hot strip mill at Geneva has a unit called a trailing-end tension compensator which cuts down the amount of over-gage material at the tail end of the strip from about 150 to 20 ft. Another unit is being planned to obtain the same results by combining speed and screw-down variations to maintain the gage at the end of the strip.

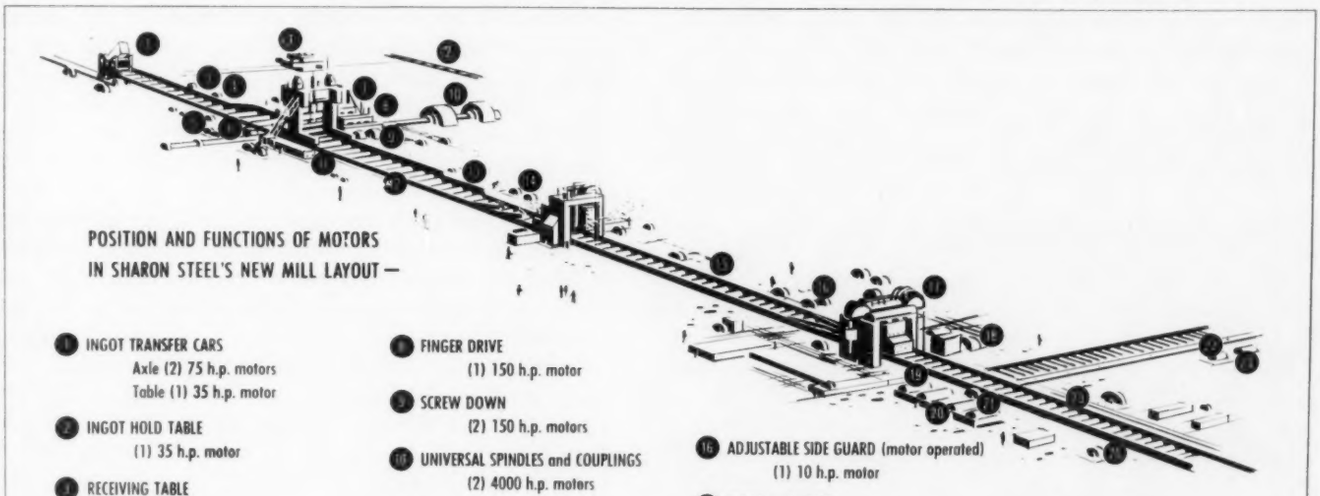
One early punch-card control system on a rougher is used on the Allegheny Ludlum 56-in. reversing roughing mill at Brackenridge. The card system on this mill is capable of controlling 15 programmed passes from a single card at accuracies of approximately 0.01 in. This control uses an electronic counter which is preset by the punched card data to regulate screw-down position. Feedback is measured by pulses from a magnetic pickup toothed disk transducer and is compared with the preset value. The error in position is converted to a proportional signal which drives the screwdown control. The maximum opening is 9.99 in. with settings provided at intervals of 0.01 in. Maximum screw-down speed is 40 in. per min.

This equipment uses 13 vacuum tubes, 25 transistors and two magnetic amplifiers in addition to the customary voltage control for the 150-hp mill-type screw-down motor. There is no automatic programming or setting of the speed of the mill.

These latter features are now receiving extensive trials on J & L's new 44-in. strip mill, which has such equipment on the reversing rougher. This unit started operation in November, 1957. Details of the equipment are fully covered in last year's development story.

Card program screw-down controls for reversing mills are also under construction for U. S. Steel Corp., Bethlehem Steel Co. and Inland Steel Co. These units use a selsyn system for positioning rather than an

Sharon Steel installed a slabbing and blooming mill at the Roemer works at an estimated cost of $14,000,000.



POSITION AND FUNCTIONS OF MOTORS IN SHARON STEEL'S NEW MILL LAYOUT —

1. INGOT TRANSFER CARS
   Axle (2) 75 h.p. motors
   Table (1) 35 h.p. motor
2. INGOT HOLD TABLE
   (1) 35 h.p. motor
3. RECEIVING TABLE
   (1) 75 h.p. motor
4. MILL APPROACH TABLE
   (1) 75 h.p. motor
5. MILL RUN IN TABLE
   (1) 100 h.p. motor
6. FRONT and BACK MILL TABLE
   1-4 rolls (4) 75 h.p. motors
   5-14 rolls (4) 75 h.p. motors
7. MANIPULATOR DRIVE
   (4) 150 h.p. motors
8. FINGER DRIVE
   (1) 150 h.p. motor
9. SCREW DOWN
   (2) 150 h.p. motors
10. UNIVERSAL SPINDLES and COUPLINGS
    (2) 4000 h.p. motors
11. FEED ROLLS
    (4) 150 h.p. motors
12. MILL RUN OUT TABLE
    (1) 100 h.p. motor
13. SCARFER APPROACH TABLE
    (1) 75 h.p. motor
14. SCARFER DELIVERY TABLE
    (1) 75 h.p. motor
15. SHEAR APPROACH TABLE
    (1) 75 h.p. motor
16. ADJUSTABLE SIDE GUARD (motor operated)
    (1) 10 h.p. motor
17. SHEAR and DRIVE
    (2) 500 h.p. motors
18. SHEAR GAUGE
    Travel (1) 35 h.p. motor
    Lift (1) 25 h.p. motor
19. SHEAR PULL BACK TABLE
    Table (1) 50 h.p. motor
    Side Guard (1) 7½ h.p. motor
    Shifter (1) 15 h.p. motor
20. SHEAR GAUGE TABLE
    (1) 50 h.p. motor
21. TRANSFER TABLE
    (1) 50 h.p. motor
22. BLOOM TRANSFER
    (1) 150 h.p. motor
23. PILER TABLE
    (1) 50 h.p. motor
24. TRANSFER TABLE MITER POT
    (1) 50 h.p. motor
25. SLAG SIDE PILER
    (1) 150 h.p. motor

electric counter. Some of these controls will be incorporated in a completely automatic mill programming system in which all mill functions are automatically controlled. In such systems the operator becomes merely a supervisor after starting the process.

There are various methods of operation. The programming can be incorporated with automatic numerical data recording and processing equipment. Production and accounting information can also be included on the programming card or on an auxiliary card for later processing of all data in standard business machines. Allegheny-Ludlum has installed such equipment on a 4-stand, tandem cold mill.

A paper given at the AISE 1957 Spring Meeting indicates that the universal mill is coming back into favor. Since the war, about fifteen primary mills have been built in the United States, mostly for rolling slabs. Of these, only a few were universal mills. At the present time, however, there are six mills on order, of which five are the universal type. Analysis indicates that the universal mill has increased productive capacity for slabs, but has the disadvantages of highest initial cost and maintenance.

Sharon Steel Corp.'s new $14,000,000, 44-in. slabbing and blooming mill was completed during the year. The mill can roll ingots from 4 to 20 tons into slabs up to 10 in. thick x 60 in. wide x 30 ft long. The mill has a twin drive with 4000 hp on each roll. An interesting feature is the installation of two television cameras to scan an intermill connecting conveyor and the mill shear table. In line with the mill is an automatic flame scarfer which skims four sides of the steel at once.

This mill is the first in the steel industry to be entirely simulated on an electronic computer prior to construction. A marked benefit of the analysis was that the tune-up time of the mill was reduced to about one day instead of the usual seven to ten days needed to synchronize the various motors and control equipment.

The mill produces a complete range of blooms from 4 x 4 in. to 18 x 18 in. and has a rated capacity of 1,200,000 tons annually. Main rolls are 46 in. in diam and maximum roll opening is 70 in.

It was reported that almost twenty per cent of all steel produced in the United States in 1957 was machine scarfed. At the beginning of the year there were about 46 hot scarfing machines in operation, and eleven more were added during the year. Of the additions, nine were for wide slabs.

More details became available during the year on Weirton Steel's new tandem mill. This is a five-stand, four-high mill with a total drive horsepower of 28,000, making it one of the most heavily powered units of its type. Top speed is over 7000 fpm and it is capable of rolling a 60,000-lb coil of 0.090-in. thick pickled hot roll strip to a final thickness of 0.0075 in.

Past experience with tandem mills has indicated that speeds had to be limited for other reasons than lack of power, such as perhaps scuffing or scratching of the strip surface at speeds over 4000 fpm. Before going ahead with the Weirton mill, an extensive study was made on the operational factors which indicated that dissipation and control of heat was a major requirement. In addition, it was necessary to develop better methods of mixing and applying strip lubricant. The work roll sizes were increased to 23 in. in diameter and this has been beneficial. The larger rolls give a greater area for heat dissipation, as well as better rigidity. The gage variation in the strip has been reduced by controlling the heat during periods when the speeds on the mill are being changed, and a valving system proportions the volume of the water to the mill speed.

Jones & Laughlin Steel Corp. put into production at the end of the year probably the fastest four-stand cold reducing mill for sheet steel. Built at a cost of $10,000,000, the mill has a capacity of 70,000 tons of sheet per month. The mill is a 77-in. mill, with a maximum speed of 3800 fpm. It can produce sheets up to 72 in. wide, and present production ranges from 0.0179 to 0.0747 in., or 26 to 14 gage. It will handle coils up to 60,000 lb.

The mill has a total connected capacity of almost 23,000 hp, believed to be the largest in the steel industry for a four-stand cold mill. Among the features of the mill are the independent electric motors, each with a separate generator for driving each of the eight work rolls in the four stands. An x-ray type gage, controlling the speed of the motors, is used to keep the mill on gage.

A new temper mill was put into operation by Youngstown Sheet & Tube Co. at Indiana Harbor. One of the unique features of this mill is that it is driven through the backup rolls which bear against the face of the smaller work rolls. This mill is a four-high, two-stand unit with 56-in. diam by 52-in. long backup rolls.

An interesting adaption of a lift truck is used for pulling roll chocks on a cold reduction sheet mill at U. S. Steel Corp.'s Gary works. The lift truck, with a special attachment, grasps the heavy chocks and removes them. If they stick, a hydraulic ram built into the attachment jars them loose. The truck handles an average of 12 pairs of chocks during an 8-hr shift, freeing cranes for other work.

Wallingford Steel Co. at Wallingford, Conn., recently added a new Sendzimir mill which permits production of precision strip in widths up to 27 in. and as thin as 0.001 in. The mill is equipped with non-contacting x-ray gage equipment which is used in a control system which automatically corrects roll pressure and roll tension to maintain tolerances. The mill uses elongation gaging equipment toaccurately measure thickness reductions too small to be detected by conventional methods. Another feature of this mill is its numerical control system. The operator inserts an IBM card into the control mechanism to automatically preset the mill to the required reduction schedule.

U. S. Steel Corp. has carried out some research work on turn-up and turn-down on hot rolling which was reported during the year. Initial phases of the work were done on a 30-in., two-high pinion drive rolling mill at the applied research laboratory, and later tests were made on a full sized mill.

From the simple hot mill passes studied, it was determined that the most significant factor affecting the amount of turn-up or turn-down of a piece of steel is the surface speed ratio of the top and bottom rolls. However, if the pass design is truly symmetrical, such factors as the angle of entry and the amount of edge working cannot significantly alter the speed ratio needed to produce the straight piece. A change in speed ratio will result in a corresponding change in curvature, whether the speed ratio is changed by transient disturbances or by adjustment of speed settings.

A new x-ray gage, which emits low intensity x-ray pulses at rates of 60 to 600 times per sec, permits instantaneous measurement of the thinness of foils made of aluminum, steel, copper and brass, plastic film and sheet or bar stock at speeds up to 6000 fpm. These materials can be checked for deviations in millionths of an inch. Each x-ray pulse provides an individual gage reading of the stock which may be as thin as 0.0002 in. Electronic counting and sorting devices can be hooked up to the gage because of its ultra-fast cycle.

Another thickness gage, developed by U. S. Steel Corp., is in use at their Fairless plant. This unit is an electric-mechanical device which translates x-ray measurements into numerals which are flashed on luminous plates. These readings can be read at distances up to 30 ft, and can also be recorded instantaneously on a printed form. One such device has been installed on the 80-in. strip mill.

As a result, the crew has quicker, more accurate readings of the finished strip's thickness. Stations showing readings are located in the control pulpit, the finisher's pulpit, and in the coiling pits, as well as the observer's desk.

It is reported also that a British steel plant is using gamma radiation for gage control on a continuous hot strip mill. Beta gages and x-ray gages have both been used on previous mills, but application is limited, since the beta gages can be used on strip only up to 0.02 in. thick and x-ray gages only up to about 0.25 in. thick. The advantage of the gamma gage lies in its applicability on steel up to 0.5 in. thick.

An automatic x-ray gage control system is used in the production of aluminum foil running in thicknesses from 0.00025 to 0.00651 in. at speeds up to 3000 fpm. Initial unit is on a west coast plant, believed to be the world's first foil line which is directed by an automatic gage control system. Foil thicknesses can be measured at accuracies of about one per cent. Thickness control is accomplished through varying the tension on the mill. Magnetic amplifiers are used to amplify the electrical signals from the deviation circuit of the x-ray gage.

At Kaiser Aluminum & Chemical Corp.'s Ravenswood, W. Va., plant, two new 60-in. mills, which can handle foil at speeds up to 3000 fpm went into operation in June. Foil as wide as 56-in. is rolled to various gages. Two other mills, capable of rolling at speeds up to 4500 fpm in widths up to 66 in., will be in operation by early 1958. Features of the mills are x-ray gage control, automatically controlled electric tension, and automatic input and output handling equipment. Light gage sheet rolling facilities at this plant went into operation early in 1957.

An unusual feature of Kaiser's Ravenswood plant is a 30,000,000-lb plate stretcher which is believed to be about twice as large as any now in operation. The unit is capable of gripping the ends of a 60-ft plate and stretching it as much as 5 ft, handling cross sections up to 640 sq in.

It is reported that a new steelmaking process is being tried in Sweden. The raw material is a normal open hearth pig iron with a low silicon content brought about by prerefining with oxygen. This pig iron is granulated in an air-water stream to particle sizes which

Largest single project in Republic's expansion at the Cleveland plant was the 45-in. universal slabbing mill.

run from three millimeters and less. This powder is mixed with a high grade iron ore concentrate in the mixer, and the powdered mixture is packed in a box of sheet steel in which holes are provided to allow the reaction gas produced during decarburization to escape. The box is heated in a suitable furnace to about 2200 F until the reaction between the oxide and the pig iron is completed.

Republic Steel's 98-in. hot strip mill was expanded to handle larger steel slabs. Mill can now roll slabs up to 75-in. wide in a straightaway rolling operation compared with previous 54-in.

There has been a great deal of interest in the automatic control features installed on J & L's new 44-in. hot strip mill at the Aliquippa plant.

New four-stand tandem cold mill at J & L's Cleveland division has individual drives and controls on each roll.

When the gas evolution stops, the hot box with the sintered iron powder is taken out of the decarburizing furnace and is rolled on a conventional two-high universal rolling mill.

To get full density, the box has to be compressed to about half its thickness, but to get the maximum strength, the steel has to be rolled to at least one-quarter of the thickness at full density. Properties of steel are said to be good despite the fact that the oxygen content may be as high as 0.10 per cent. It is reported also that the steel is free from segregation. Strip has been made by the process, as well as some square and round sections. Flat products are, however, best suited for the process.

Another interesting rolling application which rolls metal powders directly into strip material was designed primarily for processing of fuel elements to be used in nuclear reactors. It is claimed that it is possible to produce strip of high density, good ductility and high tensile strength.

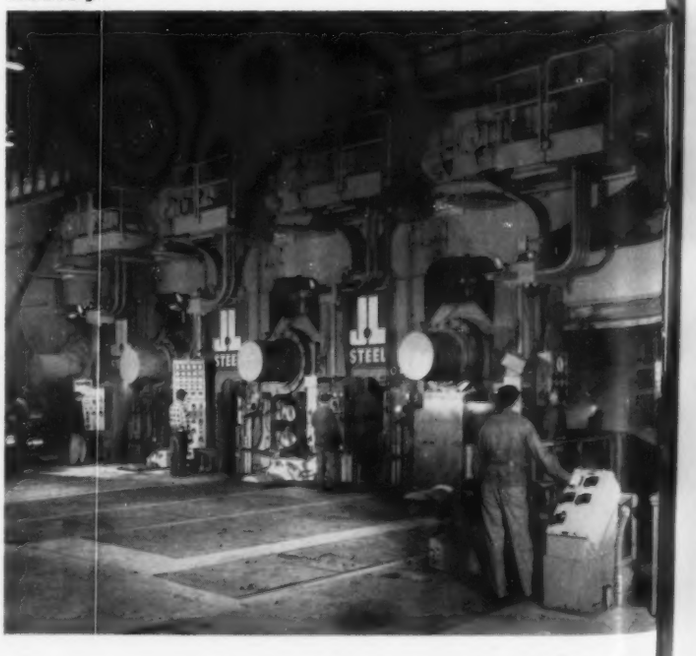
A new seamless tube mill went into operation at the Mannesmann Tube Co., Ltd., at Sault Ste. Marie, Ontario. This mill is highly mechanized and is rated at 225,000 tons per year of seamless oil well casing, line pipe, refinery, hot finished mechanical pipe and couplings. The mill consists of two rotary piercers, a plug mill, reelers and a sizing mill. It is designed to roll seamless pipe from $4\frac{1}{2}$ in. to $10\frac{3}{4}$ in. OD. The rounds are heated in a rotary hearth furnace and proceed through the piercing and rolling operations. Between the sizing mill and the cooling beds, the pipe is automatically weighed and measured by a machine which records the figures. Extensive use is made of radiation cells, actuated by the heat from the pipe itself, to control successive movements of the pipe through the mill. The mill has a connected load of more than 22,000 hp with 14,000 hp on main drives alone. The project cost about $20,000,000.

An unusual feature of the mill is the plug mill, where the designers abandoned the multi-groove roll and used single-groove rolls, with each roll individually driven by a 2000-hp, d-c motor with adjustable voltage control. This makes it possible to start each individual pass at the standard rolling speed and to increase the speed during rolling. As a result, on a 50-ft pipe, an average time gain of 0.9 sec per pass is obtained.

Another modern pipe mill went into operation in 1957 at the plant of the Alberta Phoenix Tube & Pipe, Ltd., Edmonton, Canada. This mill, built at a cost of $6,500,000, will produce more than 100,000 tons of welded pipe a year ranging from $3\frac{1}{2}$ to $12\frac{3}{4}$ in. OD. Automatic operation is obtained from the time the skelp enters the line until the pipe is loaded on the waiting flat cars in finished lengths.

The mill is divided into four zones: entry, edge

J & L's new 77-in. cold reducing sheet mill is believed to be one of the heaviest and fastest four-stand mills in the industry.



conditioning, forming and welding, cooling and sizing. In the forming section there are eleven passes, of which six are driven. The welding unit is a 750-kva, 120-cycle per sec resistance welder which can weld ¼-in. wall thickness at speeds up to 65 fpm.

Youngstown Sheet & Tube Co. started operation of its seamless tube mill at the Indiana Harbor works in October. This is the first unit for Youngstown making seamless tubing outside the Youngstown district. The mill produces tubes in sizes from 4½ to 9⅝ in. OD. A rotary furnace, installed to heat billets for the mill, is believed to be one of the largest ever built. As many as 200 billets may be on the hearth at one time. The furnace is designed to heat a maximum of 210 billets per hr at 2200 F.

High temperature silicon transistor hot metal detectors have been helpful in automating this new seamless tube mill in the Chicago area. Several of these detectors are being used to furnish intelligence to the mill control and indicate the presence of hot billets or tubes. All machines from the billet centering machine through the reelers are automatically sequenced by one or more of these devices. The new hot metal detector has no moving parts and does not require contact with the tube. It thus eliminates many maintenance problems. The silicon transistor pickup units perform satisfactorily at extremely high ambient temperatures. They can absorb large quantities of radiant heat and operate at temperatures up to 212 F.

The hot metal detector is supplied in two basic parts —a pick-up unit which includes a focusing lens and a transistor amplifier which may be located several hundred feet from the pickup without adverse effects on the operation. The device has essentially instantaneous pick-up and drop-off characteristics on steel at temperatures above 1500 F. At temperatures below 1500 F, other types of detectors already developed can be used. These older types, however, have the disadvantage that they do not function properly at the high ambient temperatures encountered in most mill applications.

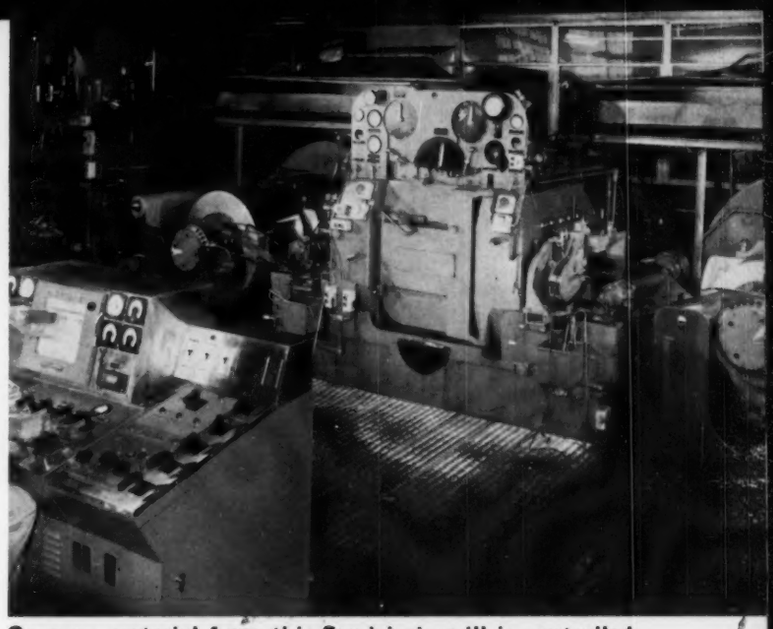
Jones & Laughlin Steel Corp. put into operation a new $8,000,000 electric-weld pipe mill at the Aliquippa works. One of the unusual features of the mill is that the electric current is fed directly to the welding transformer at 2300 volts without the use of intermediate transformers. This reduces current impedance and increases speed of response and availability of power at the weld. Another interesting feature of the mill is that the forging pressure is measured electronically, thus aiding the operator to maintain a pre-determined pressure and improve the quality of the weld.

The mill consists of a side trimmer, an edge shaver, a series of nine individually driven forming stands, a resistance welding unit, a flash trimming unit, two electric induction annealing units, three sizing stands, and finally a cutoff machine.

A tube mill at Republic Steel Corp.'s Steel & Tube Division in Cleveland uses a new welder for the production of tubing from one to three in. in diameter in wall thicknesses of 0.050 to 0.100 in. The unit is ultra-high frequency, operating up to 450,000 cycles per sec, compared with the usual 440. Advantages are that the internal bead is smaller than conventional and there is less internal spatter caused by current fluctuation.

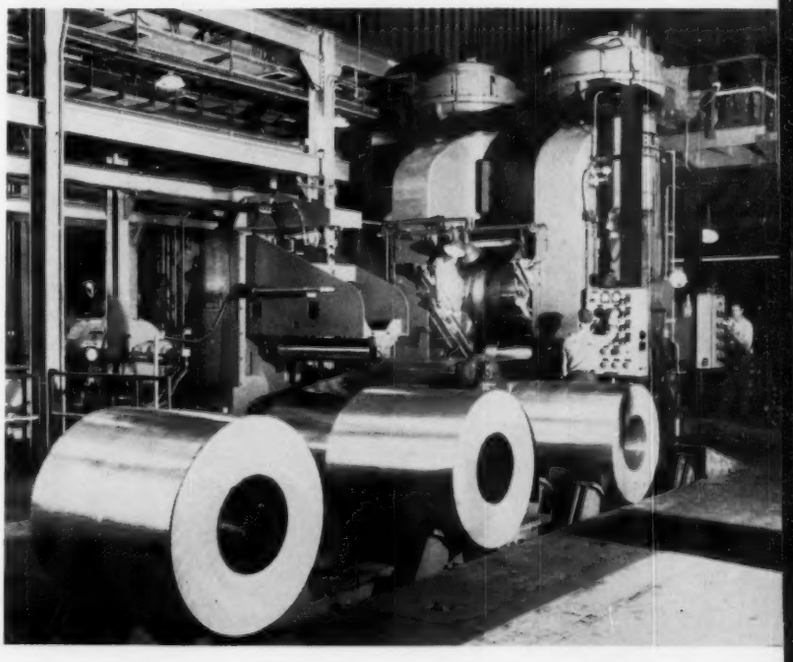
Another application of high frequency resistance welding for the manufacture of tubing was put into operation by the James Steel & Tube Co. of Miami, Fla. The unit uses roll type electrodes which bring the current to the weld area by means of two sliding contacts, one on each side of the seam. The high-frequency current heats only the edges, and when these edges are brought to welding temperature, the pressure rolls force them together to complete a forge weld. One reason for the effectiveness of the welder is the so-called skin effect. It is well known that the higher the frequency, the closer to the surface the current travels. In this welder, the current heats a thin layer along the surface, reducing the amount of heat affected zone. It is claimed also that the tubing needs no cleaning before welding.

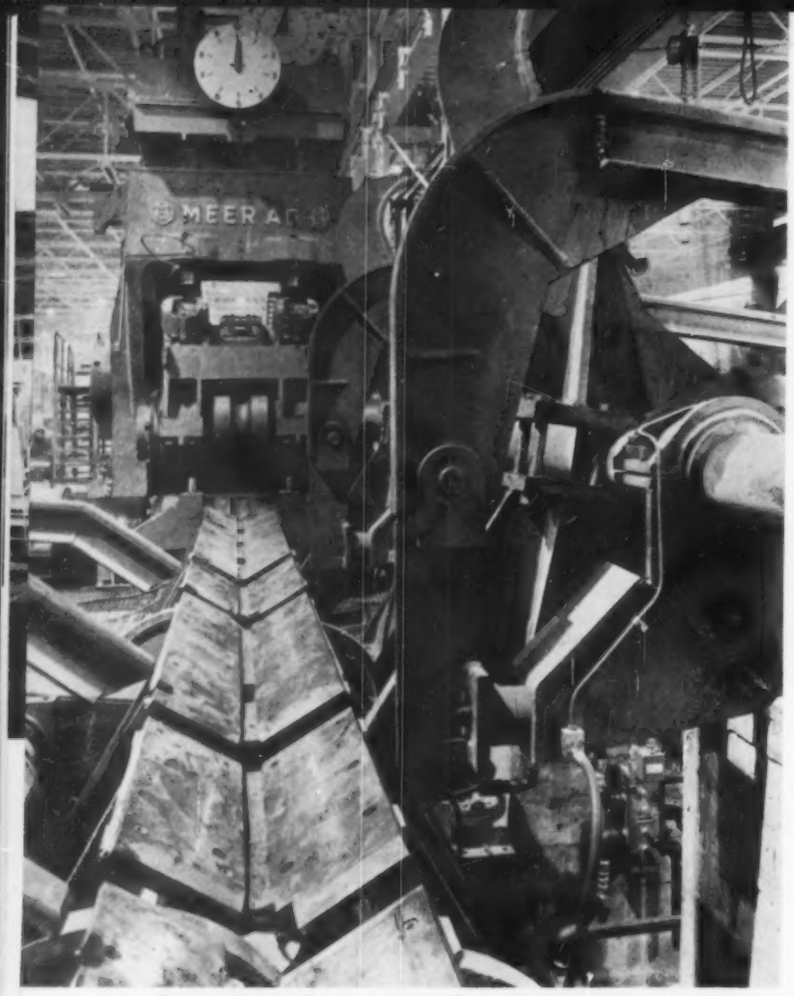
A new automatic gaging machine has been developed which will check the wall and bottom thickness of tubing and separate them into good, rectifiable and



Gage on material from this Sendzimir mill is controlled by combination of screwdown and tension adjustments.

The new No. 8 temper mill at Weirton Steel, a four-high single-stand unit, can process 30,000-lb coils of steel at speeds up to 3500 fpm.





Plug mill of Mannesmann Tube Co.'s seamless unit has a different design which results in specified pipe wall thicknesses at higher operating speeds.

A continuous weld pipe mill was put into operation at J & L's Aliquippa plant. This, the first of two units, will produce pipe from ½ to 1½ in.

rejected grades at rates up to 1000 units per hr. This automatic tube gaging machine, in operation for a year, was first devised for use with aluminum tubing.

In operation, the tubes are fed into a chute from which they are transferred to a nest of rubber rolls rotating at about 600 rpm. As the tubes rotate, gaging contacts enter the open ends, exploring the wall thickness on the helix that is generated. At the end of the stroke, bottom thickness is measured. After gaging, the slides are retracted at faster-than-gaging speed and then the contacts operate two gage heads which sort the tubes onto classification conveyors.

Latrobe Steel Co. started up a new mill for handling high speed steels and difficult-to-work super alloys. This is a two-high, 32-in. reversing mill which replaces the previous procedure of forging for shaping these hard steels. The mill uses diamond-grooved rolls rather than the usual box or flat blooming mill rolls. It can roll ingots as large as 18 in. and up to 4000 lb in weight, to sizes down to 3 in. square. Slabs up to 12 in. wide can also be handled.

Jones & Laughlin Steel Corp.'s new plant at Willimantic, Conn., went into production in June. The property for this new plant was purchased in 1955 and construction was started in 1956. Hot rolled bars from the J & L mills in Pittsburgh will be shipped to the new mill for cold drawing. The plant has a new continuous cold drawing machine which is fed from coils of hot-rolled steel, and which draws, straightens, polishes and cuts to lengths in one continuous operation.

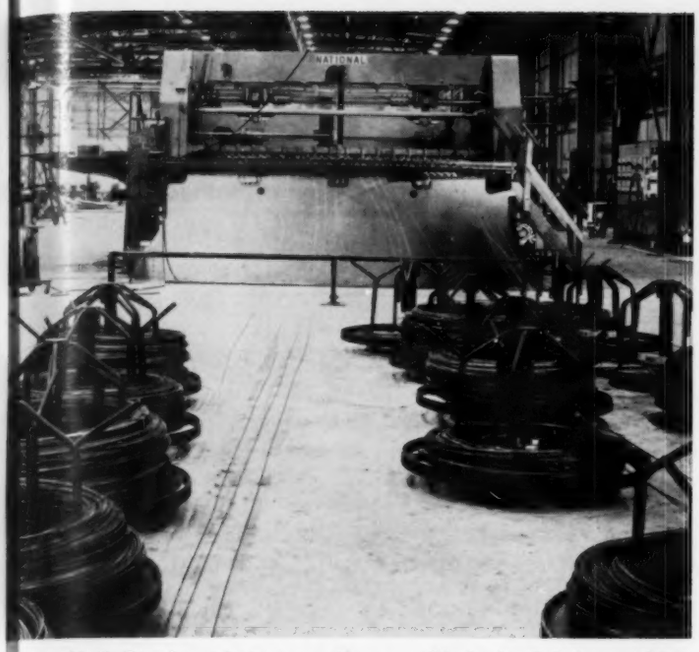
United States Steel Corp.'s American Steel & Wire Division started two welded wire fabric machines at the Cuyahoga works in Cleveland. Each machine can handle some 1700 tons of welded fabric a month.

Considerable progress has been made in mechanical, continuous blast cleaning of rod. Experimental tests have been run by several concerns over the past two years, in an attempt to eliminate acid pickling. As a result of this work, one company has installed three production lines, two other companies are each installing a line, and a fourth is operating an experimental line to get further data.

The process is quite simple, consisting of applying a metallic abrasive from several high-speed centrifugal blasting wheels to the surface of the hot rolled rod in the best manner to get required scale removal, at speeds established by subsequent processing. Preliminary figures indicate substantial savings compared with present pickling and liming methods.

Inland Steel Co. ordered what is probably the largest electronically controlled contour lathe last year. The lathe has a nominal 60-in swing and is 25 ft between centers. It will have an electronic follower control mechanism so sensitive that it can duplicate the contours of a master template within 0.001 in. The lathe will be used for dressing backup rolls and turning structural rolls. Incorporated in the machine are a number of special design features which will speed setups and changeovers, and which will provide the extra power needed to turn up to 75-ton rolls. Some of these features are a power-traversed tailstock and power-traversed neck housings with hydraulic locking clamps.

A German lathe which has been imported for several plants also speeds up roll turning. This lathe can



U. S. Steel put into operation a welded wire fabric machine at the Cuyahoga works at Cleveland.

handle pieces up to 63 in. in diam weighing up to 90 tons, and the machine can cut rough-turning time by as much as 75 per cent. The machine delivers 250 hp to the spindle. Cutters operate from two independent carriages. The lathe is 30 ft between centers.

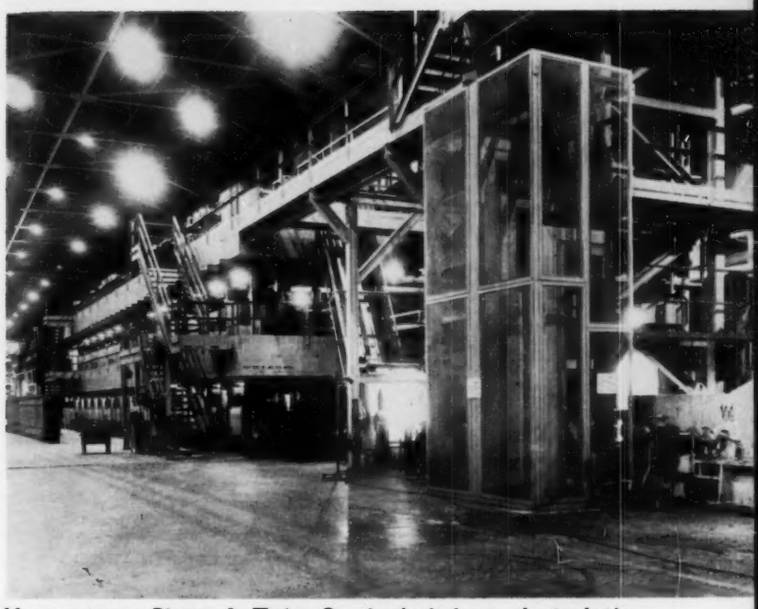
FINISHING

In 1957 the development of additional galvanizing capacity on which extensive expansion has been under way for the past several years finally reached a halt. Republic Steel completed two units at its Gadsden plant and two more lines were essentially complete at Weirton Steel Co. As a result, there is almost 3,000,000 tons of galvanized sheet capacity available in continuous hot dip lines.

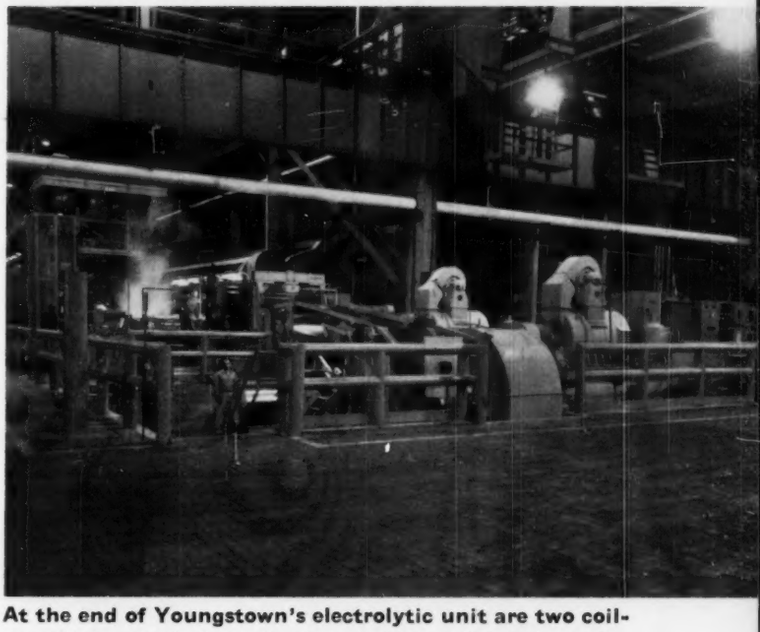
Republic Steel Corp. also revived its production of terne plate and completed a new continuous terne metal line at the Warren, Ohio, plant. Initial schedules call for a monthly output of 1000 tons of coil or cut lengths. This material is made specifically for fabricators. The unit will also produce an additional line of sheets and material for the roofing industry, as well as standard ternes for fabrication of fire doors.

The new terne production line will turn out coils up to 36 in. wide and cut lengths up to 156 in. long. It is so set up that various coating weights and combinations of base metal and coating can be supplied to meet various specifications. This is one of the few continuous terne lines in operation in the country. It includes an 80-ft acid cleaning tank, a 20-ft rinse tank and a dip tank that will hold 35 tons of molten terne metal.

Bethlehem Steel Corp. put into operation a pilot line for coating black plate which may be used as a substitute for tin plate in certain applications. The pilot line has been in operation since August, 1954. For some uses, the material is superior to tin plate because it has better resistance to alkalies. The coating gives good adhesion for other materials, is smooth and lustrous and scratch-resistant. The weight of the coating can be

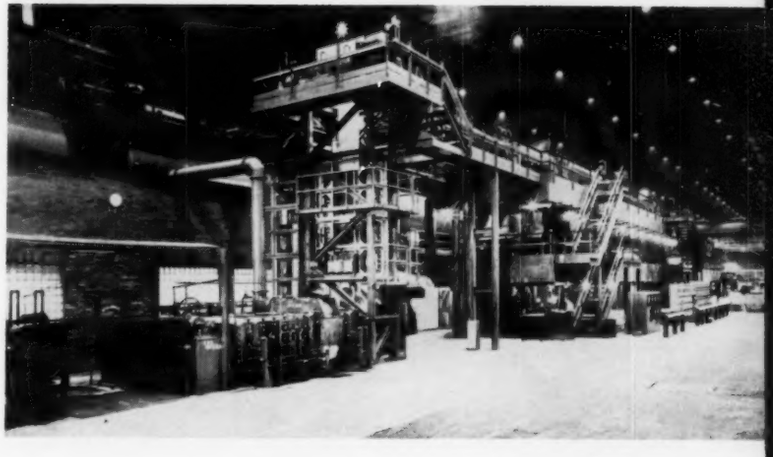


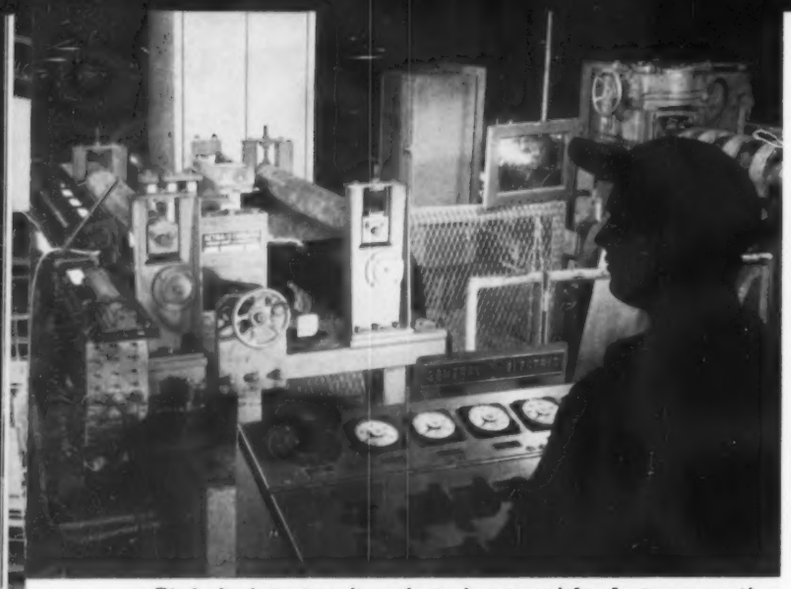
Youngstown Sheet & Tube Co. included an electrolytic line in the new tin mill which went into operation last summer.



At the end of Youngstown's electrolytic unit are two coilers which provide for uninterrupted flow of strip from the tinning line.

Weirton's No. 5 electrolytic tin plating line operates at speeds up to 2000 fpm.





Pinhole detectors have been improved for faster operation and to pick up the smaller holes down to one mil in diameter in opaque strip steel measuring 0.01 in. or less.

varied from a few to several hundred mg per sq ft. The metal surfaces, however, are difficult to solder. The line is continuous and fast.

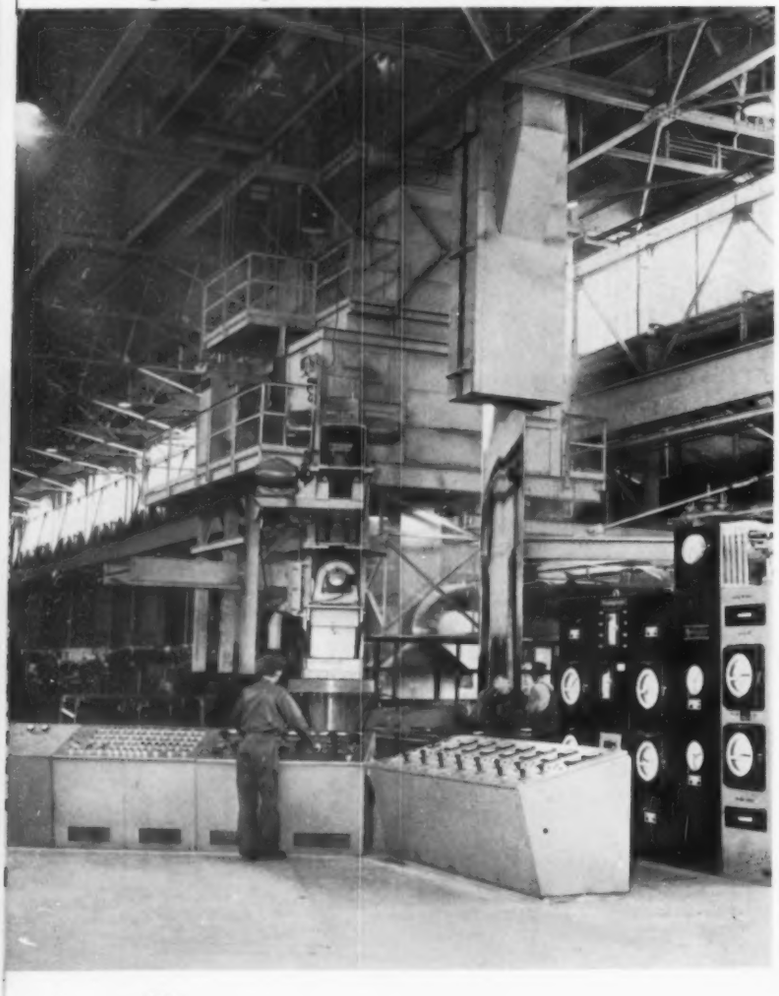
In operation, the strip goes off a payoff reel, through an electrolytic cleaner, a water rinse, an activating rinse, a water spray, an acid etch, several water sprays, a coating solution, a bake oven, cooling rolls and is then wound up on a take-off reel. The coating is an inorganic material consisting chiefly of chromium compounds. It can be applied to stainless steel, magnesium, aluminum, zinc and copper, as well as steel. Coating is done at room temperature. The pilot plant averages about 100 tons per day.

Weirton Steel Co. put a new continuous cleaning and annealing line into operation in their tin mill department and a new continuous coil galvanizing line in the sheet mill department during this year. The continuous cleaning and annealing line handles 60,000-lb coils of cold rolled strip steel up to 45 in. wide in tin plate gages and operates at speeds up to 2000 fpm. Coils from the tandem cold mill can be cleaned and annealed at rates up to 60 tons of strip per hour. An unusual feature of this line is that it is located on the fourth floor of a new building. The looping towers go down through the building to the basement floor, permitting the looping of 700 ft of strip in each tower.

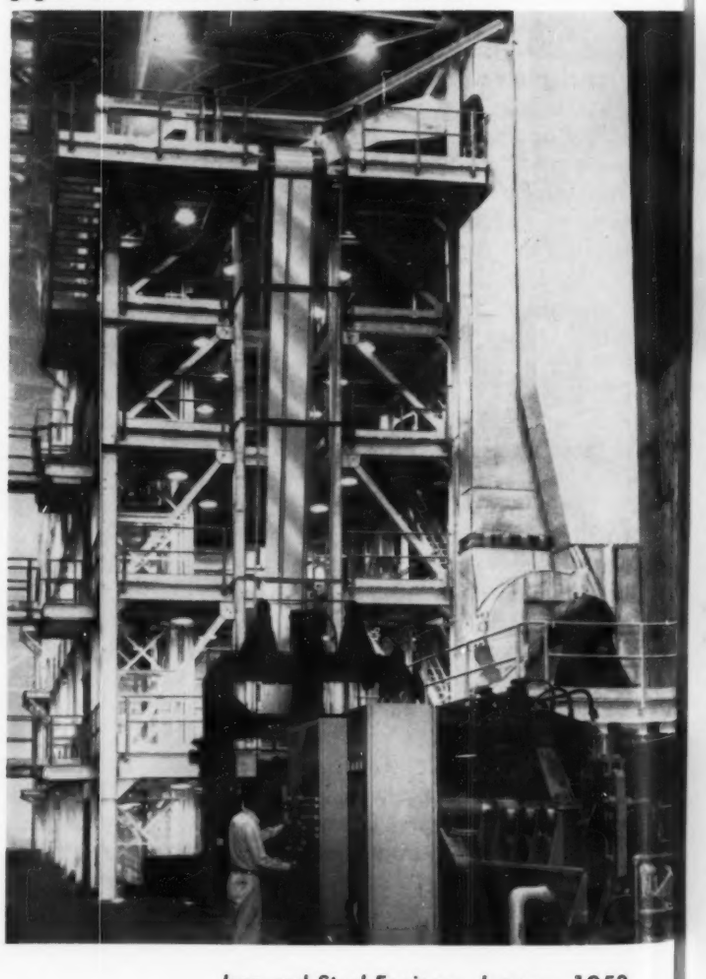
The newly completed continuous coil galvanizing line operates at speeds up to 300 fpm maximum and can produce galvanized sheets in widths from 18 to 48 in. A second similar line is now under construction. When the unit under construction is completed, Weirton Steel Co. will have four continuous galvanizing lines.

The trend to the purchase of tin plate in large coils rather than in sheets has resulted in the development of a data processing system which can be used for collating and recording in a tin plate inspection system. This equipment will collect the defect information obtained

Republic Steel started operation of a 48-in. continuous galvanizing line at the Gadsden, Ala., plant.



Weirton Steel's new No. 3 continuous galvanizing line is a five-stack annealing unit capable of handling heavy gages. Unit is rated 12,000 tons per month.



from inspection gages and will, upon completion of the coil, prepare a typewritten summary sheet of the defect totals following a fixed format. In addition, a tape or card can be prepared to provide a permanent record that is easily sorted by machine techniques.

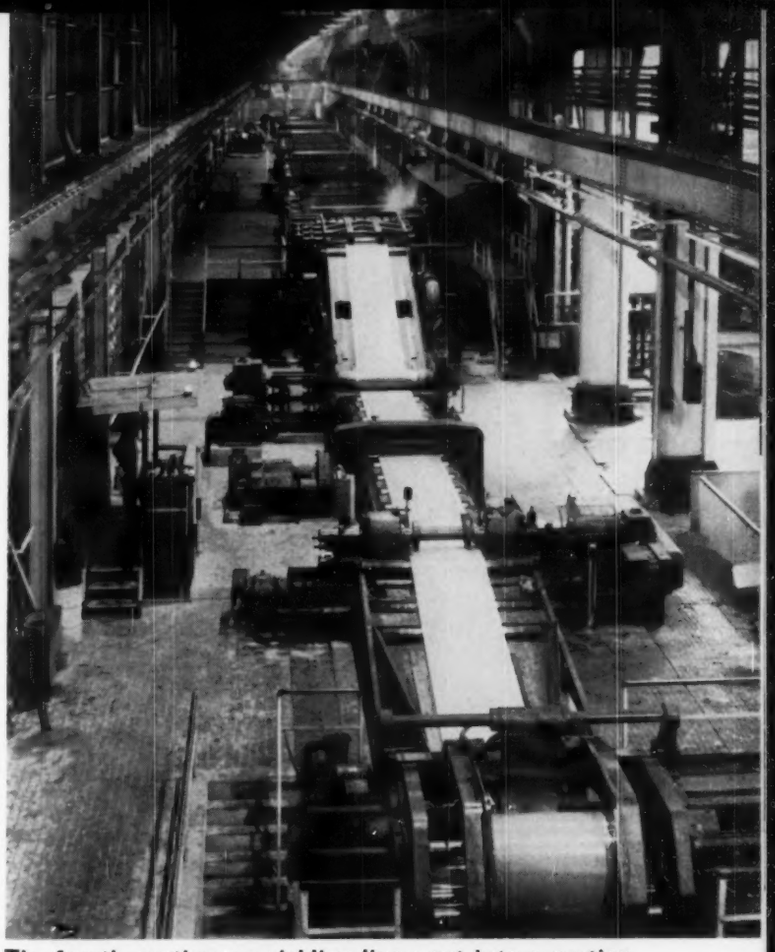
This data processing system takes the defect information from the footage meter, the thickness gage, the pinhole detector, the top and bottom coating thickness gages, and the visual inspection station. A pulse type footage meter supplies basic information to the system. Classification can also be set up in a system, with the coils being classified as prime, menders or waste.

An x-ray thickness gage put into operation at the Indiana Harbor Works of Youngstown Sheet & Tube Co. can automatically inspect and assort, according to thickness of tin plate, sheets at rates of 60 to 100 sheets per minute. This equipment checks the thickness of separate sheets as they feed off a conveyor belt. No measuring device touches the sheets, and no "memory" device is necessary because the gage pinpoints the substandard sheets. The thickness gage scans each sheet and makes possible the withdrawal of individual sheets found to be off-tolerance. This unit is now working on sheets with a minimum length of 16 in. and a maximum of 45 in., in a range of thicknesses from 0.006 to 0.019 in. Gaps between the sheets do not affect the operation.

It is reported that there is a thickness gage which will fit into the palm of the hand which can be used to make fast, accurate checks on the thickness of nonmagnetic material bonded to smooth iron or steel. Enamels, platings, coatings and paint can be measured. Low range of the double range scale is 0.007 in. and the high scale will run from 0.001 to 0.060 in.

A new pinhole detector was put on the market during the year which is capable of detecting holes down to one mil in diameter in opaque strip steel measuring 0.01 in. or less. This unit, a redesign of an earlier detector, can function at maximum sensitivity at strip speeds up to 2000 fpm. One reason for the faster operation is that up to twenty times more light is used than in the earlier unit. The light is provided by a new 2500-watt mercury vapor lamp operating on direct current to eliminate possibility of dead areas in the strip. The unit is also more sensitive in the detection of angular as well as vertical holes. The unit uses six photomultiplier tubes which have better performance characteristics than similar units which use up to as many as thirty phototubes.

It is reported in a recent patent specification that materials can be hot-dip coated with aluminum more easily if a small amount of sodium, potassium or sodium-potassium mixture is added to the aluminum bath. It is claimed that this will make it possible to increase coating speeds and to dispense with the need of fluxes for neutral atmospheres. Bath life is also increased and smoothness of coating is improved. In the process, the aluminum bath is first skimmed and a quantity of metallic sodium is plunged below the surface of the bath and stirred. After a short time, some of the sodium is absorbed in the bath and the excess is either fumed away or converted to a dross on the surface. The bath is then skimmed carefully and is then made ready for use. The bath appears to be brighter than it was

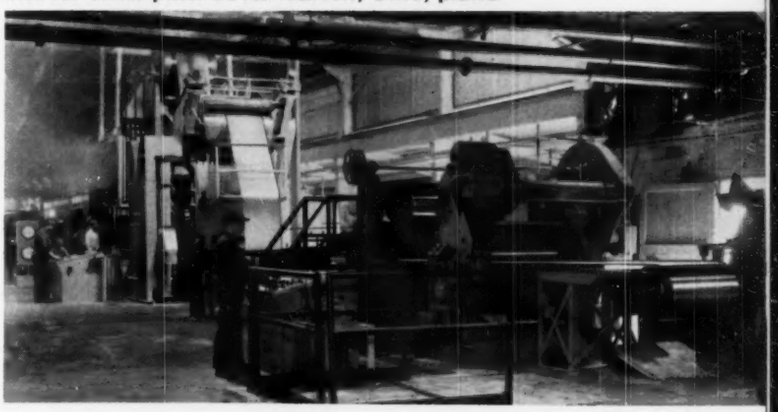


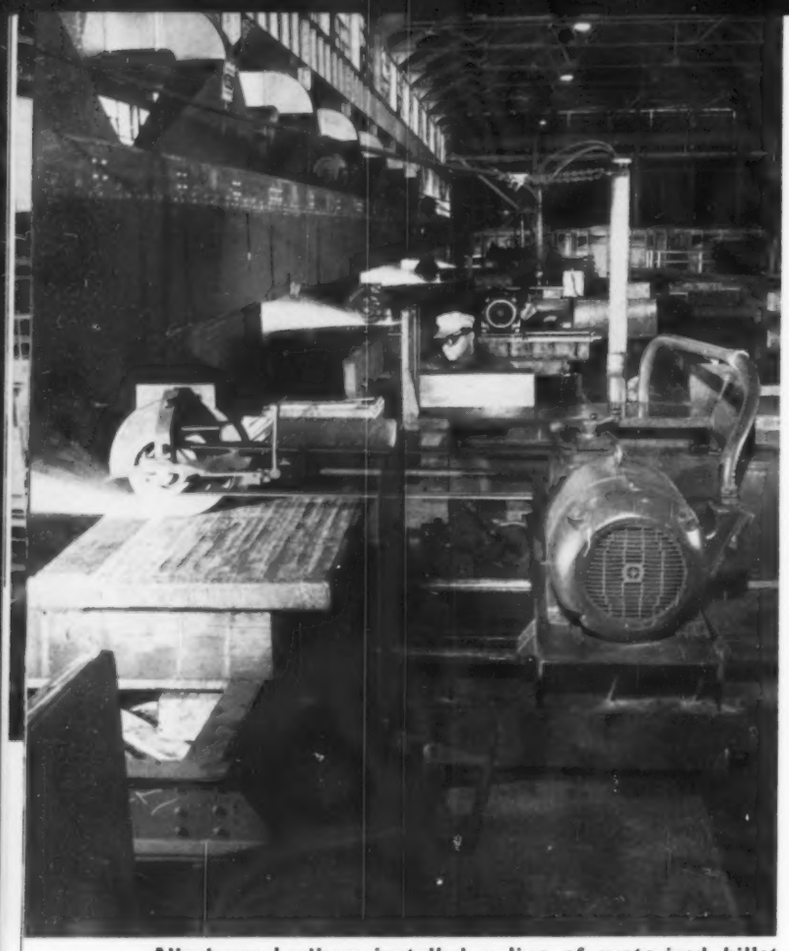
The fourth continuous pickling line went into operation in July at the Great Lakes Steel plant of National Steel. Unit is capable of cleaning strip up to 78-in. wide at a maximum speed of 500 fpm.

before the sodium treatment and remains bright for a long period of time after skimming. It is recommended that somewhere between 0.001 and 0.1 per cent by weight of sodium or potassium should be present in the bath.

Bethlehem Steel Co. has developed a practical, inexpensive process for applying a corrosion-resistant aluminum dip coat on small steel parts. Since successful coating depends on the chemically clean surface, the parts are first preheated in a fused salt to burn off any oil or grease which may remain after a prior alkali degreasing. Next comes pickling, after which the parts go to an electrode salt bath furnace, then into an aluminum induction furnace and finally through a centrifuge.

Republic Steel put into operation a continuous production line for terne plate at its Warren, Ohio, plant.





Allegheny Ludlum installed a line of motorized billet grinders at the Brackenridge plant.

FURNACES AND CONTROL

During the year the total of single stack annealing furnaces now in use in the sheet and tinplate industry went over the 500-mark. This is indicative of the acceptance which these units are getting due to the efficiency of the unit, the metallurgical control afforded, and the high rate of production.

A number of operators reported on their operations at an annealing symposium during the year. One report from Republic Steel, where both single stack and multiple stack furnaces are used indicates the single stack gives better over-all results. Normal furnace time for a full charge multiple stack unit runs from 48 to 52 hr at 1280 F minimum. On a drawing quality steel, the furnaces turn out up to about six average tons per hour for the total charge, or about ¾ tons per hr per stack. It is difficult, however, to consistently load the furnaces to best advantage.

The single stack units, which are high convection, radiant tube-type using ten vertical tubes placed evenly around the furnace, each have a heating input of 5,000,000 Btu. This arrangement gives enough input to bring the charge to temperature faster than in the multiple stack unit, thus giving increased productivity per furnace. Loading is comparatively simple. These furnaces have a capacity of 30 to 40 tons or an average of 1.1 tons per hr on deep drawing automotive body sheets. In addition, Republic has found that these units result in better uniformity in hardness and grain structure.

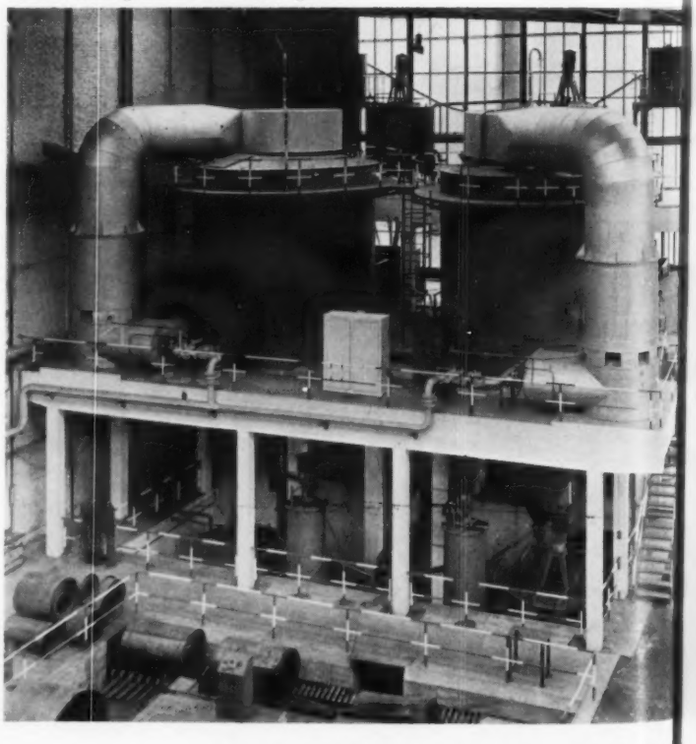
One suggestion for increasing speed of annealing is to use helium injected in the coils. It is claimed that the injection of helium into the narrow spaces which exist between the layers of coils will displace the air originally present. Substitution of highly conductive helium gas will effect a five-fold increase in the thermal conductivity of the coils radially inward or outward. This speeds up heating and cooling, and increases the output of annealing bases and covers without the use of highpower recirculating fans.

The process seems to be economically attractive, for although helium is an expensive gas, very little is needed to fill the three per cent void spaces in the coils (about ⅛ cu ft per ton of strip). Thus, even with a generous allowance for purging, the cost of the helium in large quantities should not exceed 3¢ per ton of strip.

There is continuing adoption of continuous tinplate annealing. The 1000-fpm continuous annealing line has proved to be a good practical size for production units. A 2000-fpm furnace has been built for an eastern mill. Most of the recent inquiries, however, seem to be centered on lines which operate at about 1500 fpm. There is a definite trend in these lines for water immersion or quench of the strip leaving the final cooling section at temperatures up to 600 F, as this eliminates about half of the cooling passes. Furnaces which use dry cooling can operate with a controlled atmosphere of 5 per cent hydrogen and 95 per cent nitrogen. Furnaces with water quench may have to run a little higher nitrogen to get equivalent results due to the higher dew point of the atmosphere.

The approach made by the Bethlehem Steel Co. to the continuous annealing problem is somewhat different from that of most other plants. Bethlehem has installed four continuous annealing lines at the Sparrows Point plant which give some 400,000 tons per year capacity. The whole installation is rated at 60 tons per hr for the four lines, each of which has a nominal speed of about 500 fpm, slower than most of

This plant, which uses the ferrous sulphate monohydrate process for pickle liquor treatment, has been in operation in Germany for over three years.



the lines put in by other companies. Bethlehem feels that the 15-ton-per-hr line represents optimum continuous annealing conditions.

These lines can handle strip up to 44 in. wide in thicknesses of 0.0066 to 0.015 in. They operate at a preset constant speed without slowdown for welds or coil splicing. Each line includes two payoff reels, a two-pass pinch roll, a two-pass crop squaring shear, a double seam welder and a pinch roll at the entry end. The strip then runs through an electrolytic cleaning section, a bridle roll, and a feed looping tower. Another pinch roll and a tension regulating unit precede the annealing furnace and cooling unit. Immediately following the annealing unit is a second pinch roll, the exit looping tower, a third pinch roll and a single tension winding reel.

The annealing unit consists of a single pass, gas-fired furnace which has retarded cooling and fast cooling sections. The strip enters at the top of the furnace and passes down through three separately controlled heating zones, each of which consists of a pair of panels, one at each side of the strip. Each panel is covered with a pattern of radiant burners so arranged that strip temperature is uniform as it leaves the furnace without soaking. The strip is exposed in the heating furnace for about 3.6 sec. This single pass without roll contact represents about 30 ft of effective heating length.

After going through the heating section, the strip goes through a pair of seal rolls and enters the cooling section where it is protected from oxidation by an atmosphere consisting of 4 per cent hydrogen and 96 per cent nitrogen. The strip is in the slow-cooling section about 16 sec and in the fast-cooling section 24 sec. The slow-cooling section consists of a three-pass, vertical, refractory-lined chamber, with electric heating elements and air-cooled tubes, so it can either add or remove heat. The heating elements do not function when the line is operating, but maintain the temperature during strip stoppage and prepare the unit for operation after a halt.

The five-pass rapid cooling section contains five completely enclosed water wall ducts, each arranged into three units so that the water flowing into the wall of the duct is individually regulated. On leaving this section, strip enters a dip tank where it is cooled down to about 125 F.

The fine-grained annealed steel is stiffer and stronger than batch annealed tinplate, and has improved uniformity and drawability.

The Steel Company of Canada installed a unique cascade system for precise temperature control on their continuous strip annealing line. Load changes are rapidly balanced by a master radiation pyrometer controller which resets the zone temperature controls. As the unit works, the radiation element sights the strip as it leaves the last heating zone. A second radiation pyrometer measures strip temperature as it leaves the soaking zone. In normal operation, both temperatures should be identical. A recorder-controller logs the selected strip temperature and electrically adjusts the set points of the heating zone controllers, and also the soaking zone temperature controller. If strip temperature drops below its set point, because of faster travel or increased load, the master controller automatically starts to raise the set points of individual

New continuous cleaning and annealing line at Weirton operates at speeds up to 2,000 fpm and can handle 20,000 tons of tin plate per month.

zone controllers. This increases the heat input to balance the greater load, and brings the exit strip temperature back to its set point.

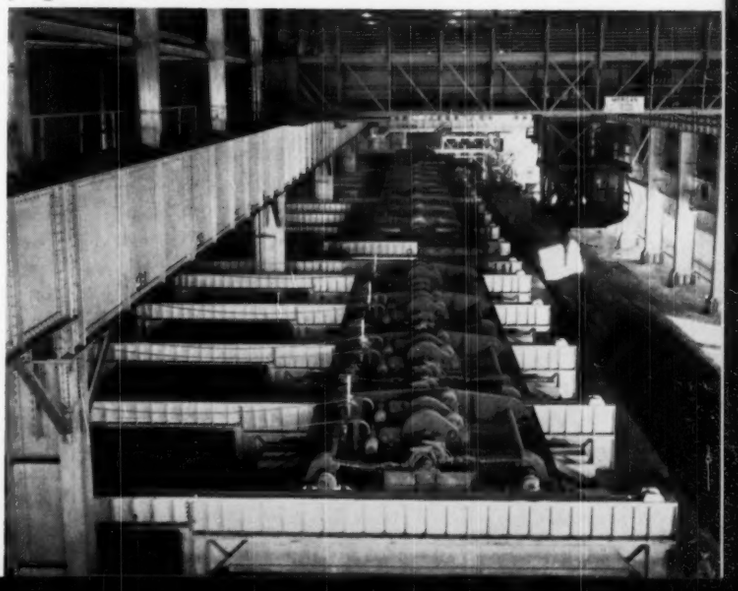
A new heat-treat unit at U. S. Steel's Homestead plant went into operation during the year. This unit can heat-treat steel plates up to 13 ft wide, 45 ft long, and 2 in. thick. It is equipped to process stainless steel, armor plate and special steels. The first furnace is a 135-ft hardening furnace which brings steel to hardening temperature. At the delivery end of the furnace is a quench, and beyond this is a 150-ft continuous tempering furnace.

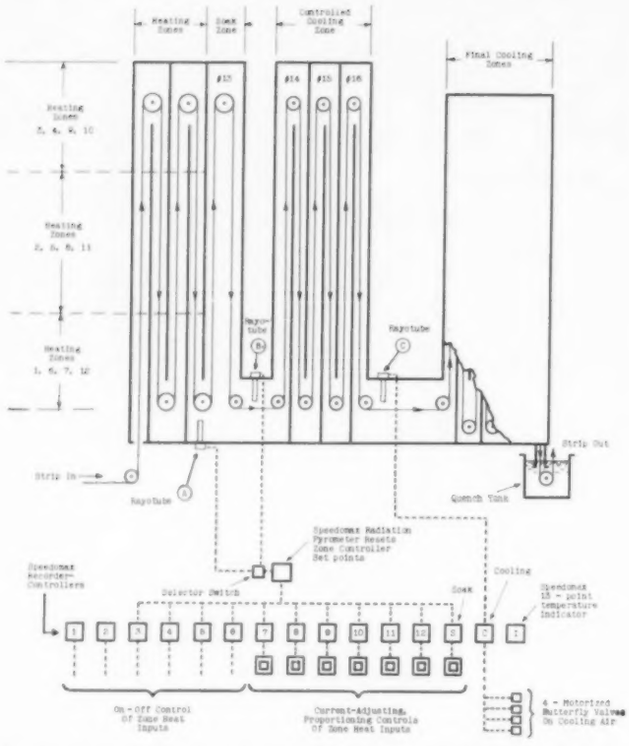
There is also a 50-ft furnace for heat-treating stainless steel, located parallel to the water quench. Maximum capacity of this furnace is 18 tons per hr. The furnace is heated by natural gas to temperatures ranging 1250 to 1750 F.

When plates are being quenched, a top movable platen is lowered until it comes into contact with the top of the plate and exerts a pressure of 2500 tons over the entire surface. This minimizes tendency of the steel to warp during sudden cooling. The platens have ribbed surfaces extending across the width of the quench, and water pipes are fastened in the recesses between the ribs. Water sprays play on the steel from top and bottom.

The tempering furnace burns natural gas and has a temperature range of from 750 to 1250 F. This unit has a capacity of 6000 tons of heat-treated plate a month.

New soaking pits were a part of Republic's expansion program at Cleveland.





A cascade temperature control system, applied to the continuous strip annealing line at Steel Company of Canada, Ltd., has been quite effective.

Allegheny Ludlum Steel Corp. increased their soaking pit capacity at their Brackenridge plant with the start-up of two batteries of four new soaking pit furnaces of advanced design. A novel feature in the new furnaces is a bin arrangement underneath the pits for removal of scale and ash from the heating chambers.

A new 80-ft diam rotary hearth billet furnace at Youngstown Sheet & Tube Co.'s new seamless mill at Indiana Harbor, Ind., has a capacity of 100 tons per hr, one of the largest of its type ever built. It is equipped with automatic charger and discharger. A new 58-ft x 70-ft 3-zone tube normalizing furnace was also built at this plant. Its capacity is also 100 tons per hr.

Republic Steel Corp. put a new heating furnace into operation on the 14-in. bar mill in the Buffalo district. This furnace, which weighs over 2000 tons, was built off the site and moved into place, saving almost two months of construction time.

The furnace was constructed on hundreds of 2¾-in. steel rollers which in turn were placed on four 12-in. H-beam skids imbedded in the foundation and leading to the ultimate furnace location. While the old furnace was in operation, excavation work for new foundations went on all around it. It took some 23 hr to push the furnace into position and the mill was down only three weeks. Closed circuit television, the first to be used by Republic, was installed on this furnace to enable the man at the discharge end to view the entry end.

The John A. Roebling's Sons Corp. have succeeded in combining patenting with hot rolling of rod. Ordinarily the rod is rolled on a continuous rod mill which produces No. 6 rod in twenty passes and No. 5 rod in eighteen passes from 2 x 2-in. billets. Finishing speed for No. 6 would be 4080 fpm and for No. 5, 3420 fpm. The distance between the finishing stands and the reels was about 25 ft, of which half was occupied by water-filled guide pipes through which the rod passes. This arrangement was the conventional water cooling used to reduce rod temperature from about 1800 to 1500 F prior to reeling.

Tests on this unit showed that by reducing the finishing speed and increasing the cooling water pressure, the rod temperature could be reduced to a black color as it went to the reels.

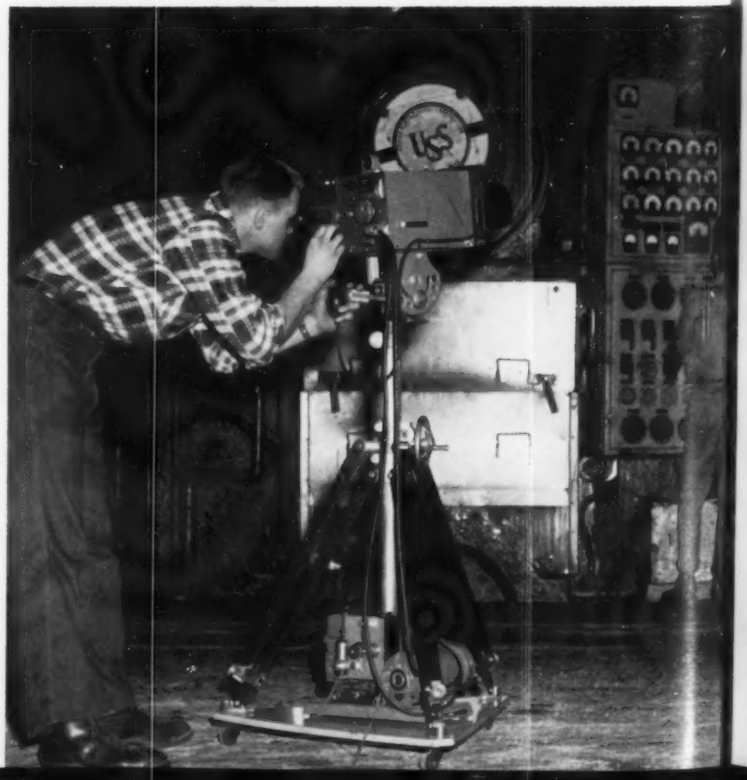
It was thus found possible to draw 0.65 per cent carbon rod treated this way to a total reduction in area of 89 per cent. The results, however, were not consistent since cooling rates produced different metallurgical structures at center and surface of rod. Computations were then made on a heat flow analog computer. These gave computed differences in temperature between the surface and center of the rod of 700 F or more.

It was therefore decided to eliminate this large temperature gradient by extending the distance between the finishing roll pass and the reels, and by water cooling the rod in four separate stages. The research laboratory made the calculations for the design in which amount of cooling in each stage is set to bring the surface temperature of the rod down to 1000 F at the first, second and third cooling stations, and to 900 F at the fourth cooling station. The space between the cooling stations was made long enough to give time for the surface and center temperatures of the rod to equalize.

In the final installation, cooling stations were designed to rapidly cool the rod down to 900 F. The temperature of the rod upon reaching the reel is in the range of 1025 to 1225 F. The cooling time is 1.6 sec. Distance from the finishing rolls to the reel is 110 ft.

It was necessary also to install automatic temperature control on the equipment. Rod now patented on this mill has not only an improved microstructure, but also less scale than conventional rod. At the present time, the product is not fully equivalent to conventional patenting, and the procedure is normally used in cases

A new thermal-imaging camera can pick up temperature differences up to one degree at distances over three miles.



where wire drawing is followed by a second patenting.

Extensive research work has been going on under the sponsorship of the International Committee on Flame Research at an experimental laboratory at Ijmuiden in the Netherlands. A number of reports on this work have been published, but it is only recently that the effects of this work on productivity in the steel industry have begun to show up.

Among the results is a quantitative report on the carburization of coke oven gas with tar or fuel oil to increase radiation of the flame. Although this idea is not new, the research work has developed certain limits beyond which there is no gain. In the case of a 100-ton open hearth furnace, this limit is about 50 per cent of the total heat delivered to the furnace. Beyond this percentage, radiation does not increase any further. In the case of a larger furnace, such as a 200-ton unit, the percentage drops, and there is little gained by carburizing beyond 35 per cent.

The British Iron & Steel Research Association has made comparison trials with a newly developed burner and burners of other designs on two all-basic 110-ton furnaces. The BISRA burner in a twin uptake furnace gave an increase in melting rate of about five per cent, an increase in production rate of about three per cent and a five per cent lower oil consumption. For a single uptake furnace, corresponding values were 2.4 per cent, 0.7 per cent and 2.4 per cent. The BISRA burner is a high steam pressure, short flame unit which permits a higher charging rate.

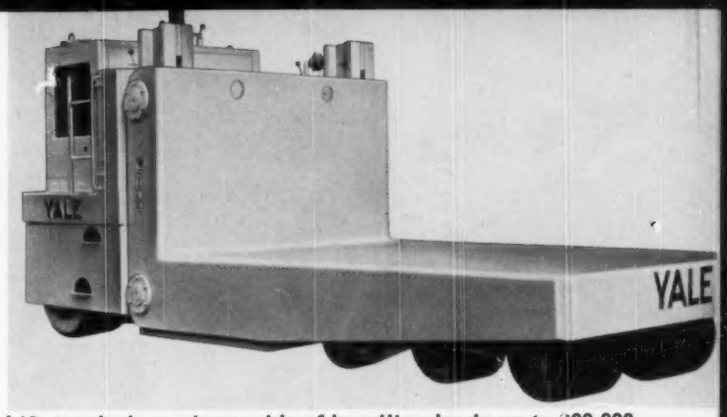
An evaporograph, which is a new type of camera, went into use for the first time in the steel industry at U. S. Steel's Fairless works. This camera forms a colored two-dimensional image by using a long wave length, infrared radiation, which is emitted from the area being photographed. The image is made visible by a light source inside the instrument. The device is so sensitive that differences of temperature as low as about two degrees F can be detected and it will function so long as the temperature is above absolute zero and there is a temperature difference in the field of view. By employing a reference temperature in the field of view, the unit can be used to determine unknown temperatures. By comparison of colors on a membrane, differences of temperature in the target area are readily seen. The device makes temperature differences visible and permits temperature measurements to be made from the images produced.

Three new instruments recently developed enable automatic measurement of streams of gases and liquids in production processes. These instruments analyze the streams so that quantitative changes in constituents are immediately recorded and controlled. The units are a chromatographic analyzer, a differential refractometer and an electrolytic concentration cell.

MATERIALS HANDLING

There were no startling developments in the materials handling field during the year.

In the crane field, a rather interesting application was the use of 27 all-welded aluminum cranes which are going into the Ravenswood, W. Va., plant of the Kaiser Aluminum & Chemical Corp. These are not the first aluminum cranes built, but a new alloy of aluminum and sigma-welding technique simplified



Lift truck shown is capable of handling loads up to 200,000 pounds.

fabrication. Some of the advantages claimed for the cranes are that they weigh half as much as conventional cranes and therefore have faster acceleration and deceleration.

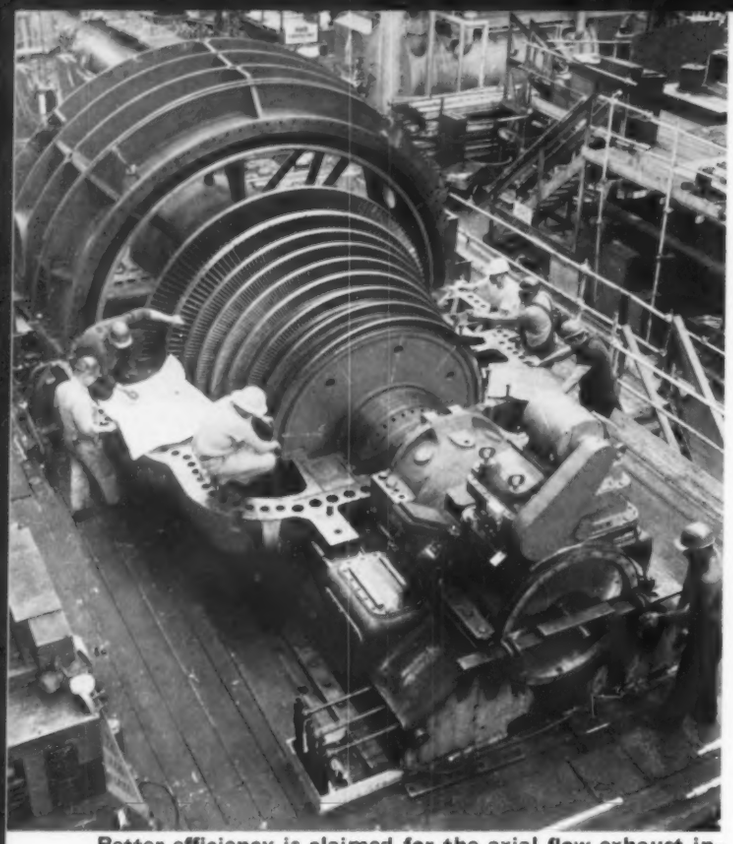
The alloy used is reported to have an ultimate tensile strength of 41,000 psi and an elongation of 18 per cent in 2 in. in the as-welded condition. The low weight means reduced building cost due to lighter construction, a feature which would not necessarily be true in an existing structure. Another saving results because cranes need no painting.

On the other hand, for stresses in the same order as steel, higher deflections must be permitted for economical design. Also the depths of the girders had to be increased over usual proportions in order to reduce the deflection. Otherwise the design was conventional. Cranes varied in size from 5 to 125-ton capacity on spans from 61 to 105 ft.

Several a-c cranes were installed at the Ohio works of the United States Steel Corp. with the object of eliminating a d-c bus system and the bulky rotating conversion equipment. One crane handles a clam shell bucket, scraping slag at one end of a slag pit, and the other handles a skull cracker, a magnet or a slag pot as necessary. A novel crane control results in a minimum of control components and also eliminates the reversing contactors. Braking is accomplished by capacitor type braking which uses an a-c motor with capacitors across the terminals.

Ladle cranes shipped during the year to an eastern steel plant reached a new high in size of 500 tons. Three such units are scheduled. They will handle a ladle having an outside top diameter of 17 ft which will hold 375 tons of hot metal with minimum lining thickness. Each of these cranes consists of four girders, with a span of 77 ft from center-to-center of bridge trucks. Each is driven by 11 electric motors, totaling 1658 hp, and has a 75/25-ton auxiliary trolley. Total weight of each crane, including electrical equipment, but not including ladle and hot metal is 1,841,000 lb. Cranes are welded steel construction throughout.

A new hoist control makes possible the elimination of the auxiliary hoist for some applications due to a dual torque design. With one set of hoisting and electrical equipment the control gives, in one hook, light load and high speed or high torque with low speed. Constant torque and speed are obtained irrespective of load on any operating point, and the unit will hoist or lower smoothly in increments of 0.005 to 0.010 in. The control uses a patented magnetic amplifier with d-c shunt motor field weakening. The unit combines constant



Better efficiency is claimed for the axial flow exhaust incorporated into this steam turbine.

speed load characteristics of the shunt motor with a 4 to 1 speed range.

U. S. Steel Corp. authorized construction of a Hulett ore unloader at their Gary works. This unloader will have a rated capacity of 20 tons and will be the ninth such unloader installed at Gary since 1906.

Of interest to crane operators is an infrared reflecting glass which will reflect up to 65 per cent of the heat rays while transmitting up to 80 per cent of the visible rays. This glass differs from the usual absorbing glasses which absorb and re-radiate some of the heat, for with the glass the heat is reflected and not absorbed. Installations of this glass increase operator comfort and protection and reduce air conditioning loads.

An interesting belt conveyor application is a battery of 25 shuttle belt conveyors to be used to load ore vessels at Erie Mining Co.'s Taconite Harbor, Minn., port on Lake Superior. The system allows the loading of as many as 10 alternate hatches simultaneously. Two vessels can be loaded simultaneously, and the complete system of shuttle belts for each vessel is operated from a central control tower.

A 108-mile coal pipeline went into operation early in the year, running from around Cadiz, Ohio, to a point east of Cleveland. The line was built to transport about 3700 tons of coal a day. Estimated cost of the project was about $12,500,000. The line consists of 10-in. carbon steel pipe and is buried under the ground to prevent freezing. Some trouble was experienced with stoppage soon after the line was put into use.

The first pipeline ever built to transport solid materials over mountainous country went into operation in Colorado. This is a 72-mile, 6-in., line built at a cost of $2,000,000 to move gilsonite from the mine to a refinery.

The line is capable of transporting 700 tons a day of ore. It is designed for continuous flow and should be shut down only after all the slurry is flushed from the system

An extremely large diesel-electric high lift truck built during the year is capable of handling loads up to 200,000 lb. This truck was designed to handle large dies in a forge shop. The total weight of the truck alone is 77,000 lb.

MECHANICAL

In the field of power, the most exciting news continues to be centered on nuclear power. Although extensive work is under way in this field, there were apparently no unusual developments during the year which would have any particular effect on the steel industry. If any trend has been evident in the nuclear power field within the past year, it is that application will not come as fast as originally thought, even though some units went on the line during the year. The reason for this is that the power plants now under construction or going into operation have required appreciably more time, capital investment and development expense than first thought needed, thus moving economical application further into the future.

In 1957, at least 21 American firms were either building or had orders to build nuclear reactors for the production of electricity, for propulsion or for research. Some 59 new nuclear reactors were either in construction or negotiating stages for private buyers in this country, for government or for export. Of these 59 new reactors, 29 are for power production and 30 others are for research and testing. In addition to this, work was under way on 17 reactors of various types for which contracts were awarded prior to 1956.

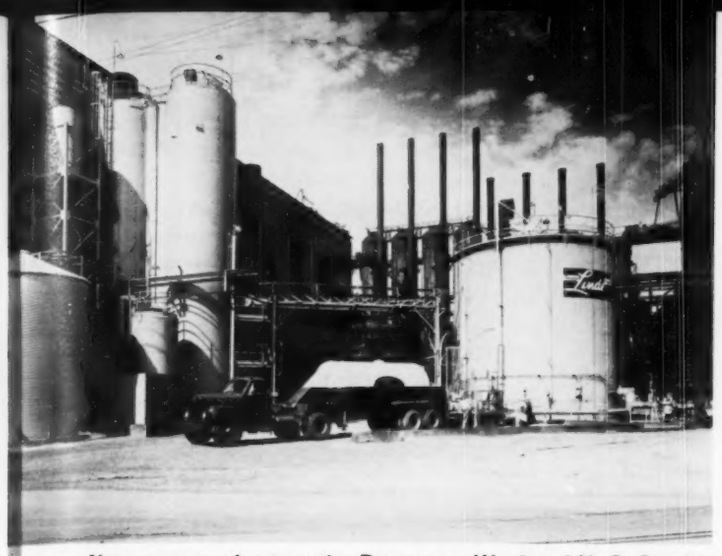
Admiral Lewis L. Strauss estimates that nuclear power will become competitive with conventional plants in most sections of United States in another 20 to 25 years, at which time he estimates there will be some 227,000,000 kw of installed nuclear capacity or about one-third of our entire national output of electricity.

Of the full scale civilian power reactors, the two scheduled to go on the line in 1957 are a pressurized water reactor being built for the Duquesne Light Co. at Shippingport, Pa., a 60,000-kw unit, and a 5000-kw boiling water type unit for the Pacific Gas & Electric Co. at Pleasanton, California. The Duquesne Light unit was developing power in December.

Initial capital costs of nuclear plants today range from about $300 to $400 per kilowatt capacity compared with $115 to $180 per kilowatt for a conventional plant. Future developments are expected to lower the cost of the nuclear plants.

One interesting development in nuclear power is the so-called packaged reactor which has been developed for the U. S. Army. This is a light water moderated, fully enriched uranium, heterogeneous unit, which was designed to produce about 1900 kw of net electrical power. For heat cycle pressurized water is used. The components of this unit approximate closely, except on a smaller scale, those used in a power generating plant using conventional fuel. The unit was developed for use primarily in remote locations where conventional fuel and heat are not available or easily accesible.

An improvement in steam turbine design was announced during the year in which the steam is ex-



New oxygen plant at the Duquesne Works of U. S. Steel is rated over 500 tons per day.

hausted horizontally along the axis of the turbine shaft. Described as an axial flow exhaust, it improves the efficiency of the turbine, with a second advantage of reducing the cost of the station itself. The turbine in its first application is a cross-compound, single-flow reheat type with axial-flow exhaust. Steam enters at 2400 psig and 1050 F. The high-pressure unit rotates at 3600 rpm and the low pressure at 1800 rpm.

Looking ahead at the steam cycle, some designers believe that increases in throttle pressures beyond 5000 to 6000 psig and temperatures about 1050 F, used separately or together, may be uneconomical. However, in many plants additional advantage can be taken of the gains in the low temperature end of the steam cycle. This will involve the use of longer last stage buckets, double flow in place of single flow in the low-pressure element, installation of a larger condenser with the larger last stage area, and the installation of supplementary cooling towers to offset hot summertime cooling water. Such refinements may give from one to three per cent greater plant capability and corresponding fuel savings.

A southern power plant combines a gas-turbine with a steam-turbine. A 5000-kw, simple-cycle, single-shaft gas turbine exhausts into a steam boiler to develop 600-psi, 825-F total temperature steam for a 12,500-kw steam turbine generator. The maximum capability of the combination is about 17,500 kw. Pulverized coal is used to provide supplementary firing in the boiler to give additional steam. Natural gas is used as fuel in the gas turbine. Normally the gas turbine exhausts at 840 F and provides the heat to operate the steam boiler without using supplementary fuel.

The U. S. Steel Corp. ordered a 125,000-cfm gas turbine for blowing blast furnaces at its South Chicago plant. This will be the first such installation in the steel industry. It is due for operation about June, 1958. Operating on blast furnace gas, the unit is expected to give significant savings in capital and operating costs. The gas compressor will deliver 125,000 cfm of air at 35 psi pressure.

Several developments last year on the turbo-charged, free-piston engine mark an important advance in motive power design. The free-piston engine produces pneumatic power in contrast to the crankshaft engine which produces mechanical shaft power. The pistons are free to bounce in their cylinders. Although they are restricted by the cylinders, they are not restricted by any linkage through connecting rods to a crankshaft as are the pistons of a crankshaft engine. This type of engine is one of the most efficient users of fuel ever developed, and can burn a wide range of fuels.

Promising applications are expected to be stationary and mobile power plants, locomotives, farm equipment, construction equipment, etc. Power outputs range from 125 up to 1000 shaft horsepower when gasifiers are used in multiples. Such a unit can also be made directly reversible and will provide reverse power up to 65 per cent of the forward power rating. It is claimed that the units can operate at temperatures of about 1000 F, which is lower than the gas turbine cycle. Other advantages are that these engines consume about half as much fuel at full load as some of the more conventional units, and give immediate high torque characteristics.

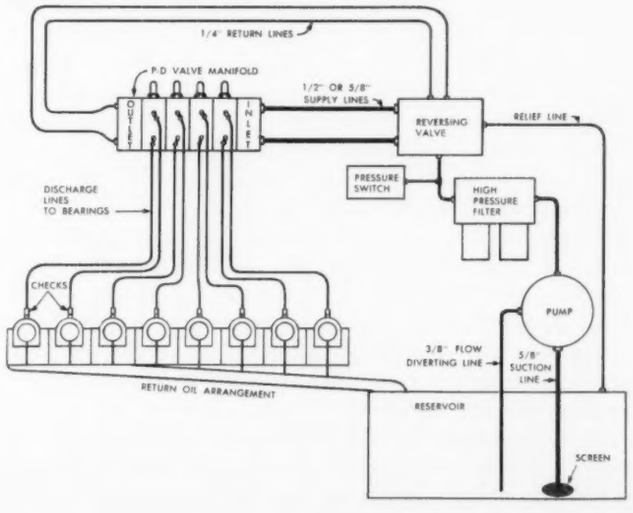
The Ford Motor Co. started operation of an experimental tractor operated by a free-piston turbine engine. General Motors Corp. also built a free-piston gas turbine unit rated at 6000 shaft horsepower which is to be used to propel a 9000-ton ship.

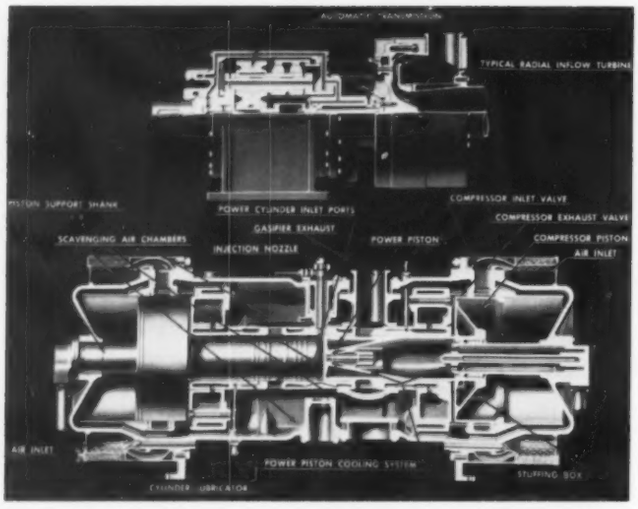
A new dust collector unit, installed in several plants during the year, is a wet inertial impingement type for which is claimed an efficiency greater than any comparable wet type collector. Test figures show that the unit has an efficiency of 99-plus per cent in collecting dust particles of five microns or greater.

Prototype models have been in operation in a number of plants. One steel plant application is at the Brackenridge works of Allegheny Ludlum, where units have been set up to collect dust from a new slab grinding operation. In this department, four of the new collectors, rated at 48,000 cfm each, are said to obtain effective dust control. These units collect the air from seven new swing grinders through a hood which connects to duct work leading to the collectors.

The collector is essentially a cylindrical device having two essential parts, a mixer section and an eliminator section. The dust laden air or gas enters the unit at its mixer section where impingement takes place. Each dust particle is enveloped in water as it passes through a fine spray. The air and entrained water-enveloped dust pass through turning vanes as they enter the

Schematic diagram shows operation of centralized unit designed for circulating oil.





Important developments are underway on the free-piston engine.

eliminator section. These vanes impart a helical motion, setting up a centrifugal force which dynamically separates the entrained particles from the air. This dust-laden water is captured at the periphery of the eliminator section in blind louvres connected to a disposal sump at the bottom of the unit.

The National Supply Co. installed at a cost of $125,000 what is essentially a giant vacuum cleaner to serve the electric melting furnace department at their Torrance, Calif., plant. This cleaner uses 780 15-ft bags and is capable of moving 75,000 cfm of dust-laden air. Each bag is 15 ft long and 6 in. in diameter, and is made of dacron. They act much like the bags of household vacuum cleaners, filtering out the dust from the air which passes through them. They are operated on a sequence basis. Once an hour, one section at a time is automatically shut off from the system for ten seconds, during which time the bags are shaken vigorously, causing the dust to fall into a collecting hopper at the bottom. From the hopper, the dust is carried by conveyor to a discharge chute where it is mixed with water to form a sludge. This plant has three electric melting furnaces.

An electronic development has brought complete automation to the power supplies of electrostatic gas cleaning systems, eliminating the usual manual and visual electrical controls and replacing them by continuously acting feedback servo-circuits. The principle behind the operation is that precipitators are most efficient at the highest voltages and power inputs, which are, however, limited by sparkover between the precipitator electrodes. Since best performance occurs at voltages well above the threshold for sparkover, the control system functions by monitoring and readjusting the spark rate to maintain optimum voltage and power input, since the optimum voltage and power input will vary with changing precipitator conditions such as temperature, flow rate, composition and humidity of the gas being treated, and size and resistivity of the particles being removed. Formerly, adjustment of each electrical set in a precipitator installation was made manually by an operator at a control panel.

A static programming was also developed which performs the same functions. It can be applied to both existing and new installations.

In the lubrication field, a centralized unit has been designed for circulating oil, particularly applicable for automatic and semi-automatic machinery. In the event of a fault, it warns the operator and it can be so set up that it will shut down the machine. In the system, oil is pumped from a reservoir to a network of bearings and then returned to the reservoir for reuse. The warning system is tied in with the pressure; in the event the pressure would drop, as in the case of a line break, the operator is warned. In the event a line is clogged, the pressure will build up with the same effect.

Oil flows through a high pressure filter into a reversing valve. The reversing valve sends the lubricant through one line at one time, and through a second line on the second half of the cycle. Both lines feed measuring valves for delivery to the bearing points. The measuring valves are linked together in manifolds and each valve feeds two bearings, one during each of the cycle halves. Valves have individual sight indicators and feature the positive piston displacement method of feeding lubricant.

The life of cold rolling coolants is often limited by contamination due to pickup during operation. Ordinarily, operators will let contaminants build up to the point where coolants are no longer usable, or perhaps use by-pass filtering systems which merely slow the contamination process and prolong the interval between tank cleanouts.

However, in the past two years, magnetic separators have been very effective. Tank cleanout times have in some cases been increased from weekly to as little as three to four times a year. The magnetic separators, of course, handle only magnetically responsive materials and filters must be used for those which are inert.

A new arc welding process effectively combines a flux-cored electrode and shielding gas to give low cost welding of mild steel at a high rate of deposition and travel speed, with excellent penetration. Flux additive, which is contained in granulated form in the core of the welding wire, has an ionizer to stabilize the electric arc, a deoxidizer to permit welding without removing scale, and a slag-forming agent. The gas shield is active carbon dioxide. This method will weld a full thickness of ½ in. in solid steel plate in a single pass.

Another new semi-automatic welding technique uses a magnetic wheel and carbon dioxide gas with a bare wire electrode. This method permits continuous welding of carbon steels and eliminates the start-stop cycles normally required with flux-coated electrode sticks. The carbon dioxide acts as a shield at the nozzle to prevent atmospheric contamination which would give weld porosity. The flux is fed through an orifice to a magnetic wheel from a pressurized dispenser, and a rubber wiper forces the particles into a carbon dioxide gas stream which conveys the entrained material to the welding torch nozzle. The bare wire is fed from a coil in a pay-off pack by motor driven feed rolls geared to the magnetic wheel. This permits adjustment of the wire-flux ratio, and also provides a continuously controlled supply at the welding arc. The electric current in the wire supplies the magnetic field at the point of weld to give proper coating of the electrode surface. An electronic control unit regulates the sequence of starting and stopping the current, wire, flux, and gas, and maintains correct welding conditions.

A family of basic materials, called pyrocerams, was announced during the year. This is a crystalline material made from glass, forming a group which can be made with a wide variety of properties. Unlike most high-strength, high-temperature crystalline materials, these products can be formed and are adaptable to mass production. They have excellent mechanical strength (flexural values up to 60,000 psi), good electrical properties and good thermal shock resistance and hardness. A factor which gives good shock resistance is that the expansion coefficients can be varied from a negative value up to about 0.0000002 per degree C. This low coefficient reduces thermal stresses and strains. The material is lighter than aluminum, harder than carbon steel, and has a high modulus of elasticity.

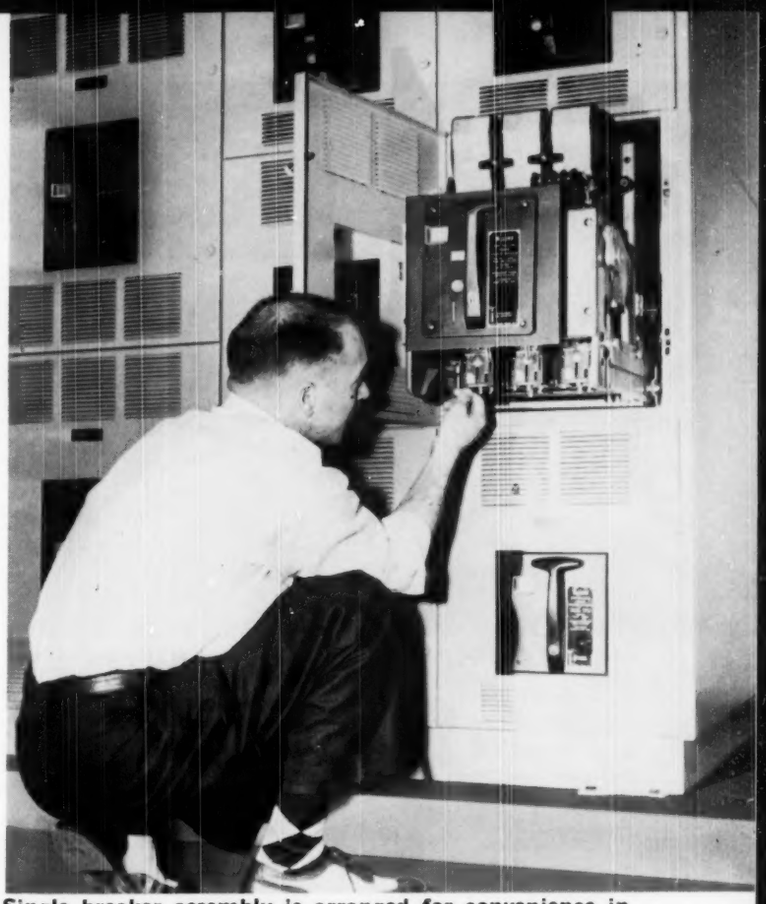
In the last year the commercial manufacturer of diamonds has become a reality. Although diamonds are important for a number of applications, the manufacturing methods indicate that entirely new materials can be made by similar processes, which may be harder and better than diamonds for many applications. Such materials are entirely new, and so far as is known, have never been found in nature. One of these is a cubic boron nitride which will scratch diamond with ease and remain hard at temperatures where diamond literally burns up. Pressures above 1,000,000 psi and temperatures over 3000 F are used in the manufacturing process.

Many types of computing machines have been developed to perform elaborate computations, giving the engineer tools for analyzing more speedily and more carefully the problems of modern operations. At the other end of the scale, several small special purpose analog computers have been developed which can be operated by the average clerical worker after relatively few hours instruction. Essentially, these computers can be used for any type of problem requiring multiplication of two numbers and summation of the results. Production yields and analyses can be determined on the equipment.

In addition a number of computer centers are being established at various areas both here and abroad, to which difficult problems can be brought for solution. Some of the steel companies have also set up centers for their operational and research uses.

One steel company is using a newly developed protective clothing made of aluminized asbestos cloth to hurry up open hearth work, since protective clothing made of this material permits the workman to go into furnaces earlier than is normally possible. This material is capable of withstanding 2500-F flame and reflects more than 90 per cent of the radiant heat.

Elaborate computing centers provide valuable tools for the engineer in analyzing problems.



Single breaker assembly is arranged for convenience in operation and maintenance.

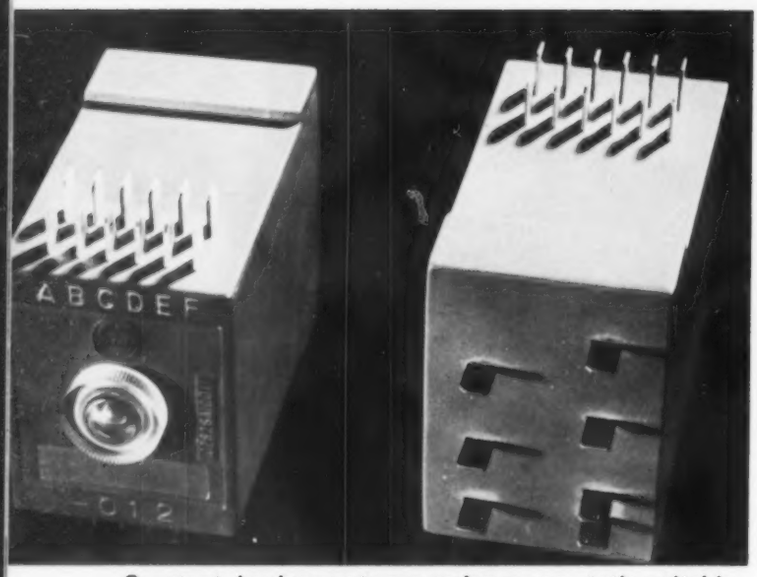
A new cloth made from a ceramic fiber manufactured from aluminum silicates is now available as yarn, cord, rope, tape, broadwoven fabrics and other forms. This material will withstand temperatures up to 2000 F and is a good thermal insulator. It can be used in flame barriers gaskets, protective clothing and conveyor belts.

ELECTRICAL

Radical innovations in steel plant equipment were largely centered in the electrical department. Complicated electronic circuitry, computing systems, static control and punched card systems are largely in the field of the scientific electrical engineer. To many practical steel operators, some of these innovations seemed unduly complicated, delicate and out-of-place in the steel plant. To add to his problems, it is difficult to attract men into the steel industry who are sufficiently trained and familiar with the equipment to maintain it.

Estimates on future power needs increase by the year, and the latest prediction is that installed capacity must meet peak loads of some 625,000,000 kw for the United States in another 20 years. The electrical industry used to figure that power usage would double every ten years. Now it seems to be doubling every seven years.

One official estimates that some 450,000,000,000 kwhr of electrical power will be needed for American industry in 1963, which is 12 per cent more than the prediction made for 1963 three years ago. The utility industry has purchased some 19,000,000 kw of generat-



Constant developments are underway on static switching units.

ing capacity annually for the past two years. By 1963 it is estimated that total power generation of Class I utilities will be about 950,000,000,000 kwhr for all purposes.

Starting in 1957, total generating capacity of public utility central stations was 120,500,000 kw and industrial was 30,000,000 kw.

According to a recent estimate, the electric utility industry has added about 8,500,000 kw of generating capacity in 1957 and plans to add 16,400,000 in 1958.

Some rather sweeping design advances feature new low voltage circuit breakers and switchgear. The new low voltage power equipment has quick-make manual closure, closed-door draw-out operation and subassembly breaker construction, all of which will permit easier and faster parts replacement. The equipment also features four-high stacking of 600-amp frame size, a new semi-flush pull-down handle and stored-energy electrical closure that cuts down the secondary circuit requirements. In general, it has greatly increased accessibility for operation and servicing. Equipment is available in 600-volt units in 225- 600- and 1600-amp sizes. The new breakers are one-third smaller and 55 per cent lighter than comparable units.

A convenient means of measuring the temperature of generator field windings by using a Kelvin double-bridge circuit with standard indicating recording instruments has been developed. This unit will successfully measure field winding temperatures of all electric generators used for present day generation. It can also be applied to the measurement of field temperature of synchronous motors, d-c motors and generators, synchronous converters and synchronous condensers. Since the resistance of copper or aluminum conductors change with temperatures, the average temperature within the winding is closely determined by means of resistance measurements with a Kelvin double-bridge circuit. A recorder is also used with the instrument system.

An electric drive system for Youngstown Sheet & Tube Co.'s blooming mill will enable the mill to reverse from 50 rpm to 50 rpm in only one second. Electronic computer studies aided in the design. This drive consists of a 12,000-hp twin drive motor and a 10,000-kw motor-generator set with accompanying control, ventilating and power distribution equipment. The drive has inverted arrangement of the twin drive units which will aid in maintenance. This places the front motor above the spindle shaft extension to the back motor, and each motor is equally accessible. The mill has a specially designed static switching system. The drive will be installed sometime in 1958 at the Brier Hill plant.

There has been further application of magnetic amplifier regulator control on tandem cold strip mills. In 1957, one such control was installed on a three-stand, 80-in. mill having a total drive hp of 13,000 in Ohio, and a similar control was installed at Wheeling Steel Corp.'s Yorkville, Ohio, plant on a five-stand, 48-in. mill with a total hp of 22,500.

Two years ago an automatic gage control system was placed in operation on a five-stand tandem cold mill in the Chicago district. This system consisted of a coarse control on the screws of the No. 1 stand which jogged the screws and a continuous regulating type control which controlled speed of the first, second, fourth and fifth standards from an x-ray gage following No. 5 stand.

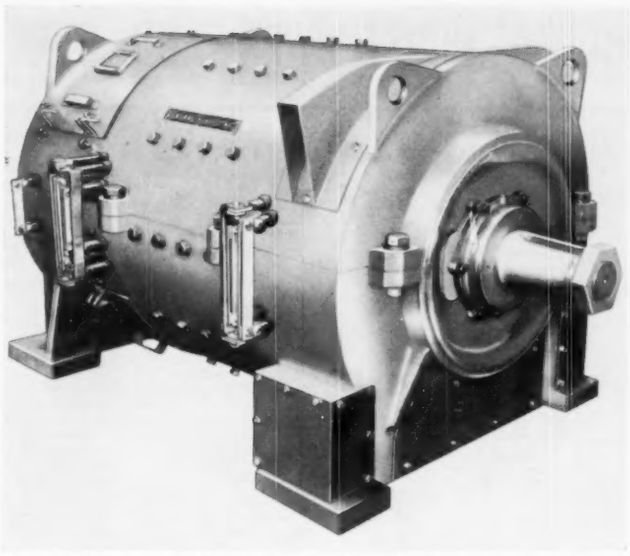
In the past year this control was rebuilt to make it essentially a magnetic amplifier system. Both regulators were tied together in a system to give fast transient response with the direct acting regulator, and to give an extremely high steady state gain with the integrating servo. The performance of the system has shown that the choice was justified. On mill acceleration and deceleration, where gage error tends to be large, the direct acting regulator supplies practically all of the corrective action. However, when the mill is up to speed and errors in gage are rather small, and the strip thickness changes gradually, the integrating servo furnishes practically all of the corrective action.

The system is very versatile. It can use an input signal from any measuring device which will operate a standard meter, and it can supply a correction voltage to any one or any combination of control devices. This gage regulating system may be applied to any rolling mill where gage can be controlled by tension.

An application of a static switching system to a slabbing mill was under way at the end of the year. This mill, being built for Inland Steel Co., is to be driven by a 12,000-hp, double-armature, twin drive motor and a 4000-hp, double-armature edger drive motor. In addition to the mill and edger control, the mill tables, feed rolls, manipulator rams, manipulator fingers, edger roll screws and mill screw-down are all being provided with a static switching system which replaces the relays that would be required to operate on every pass. Card programming is also being applied to this mill.

Several functions of the mill will still use conventional relays where static switching is not considered advantageous. These include protective circuits such as overcurrent, overvoltage and field loss, and jogging and circuit breaker control. This selection is in line with the conception that static switching is useful where frequent or continuous operations are needed, or where complex systems or adverse atmospheric conditions exist.

As horsepower has been increased on hot strip



The AISE approved standards for additions to its line of mill motors which bring ratings up to 500 hp.

finishing mills, the possible damage from d-c short circuit currents and resulting forces have posed problems in the design of d-c bus systems. The trend has been to split the bus into sections to obtain lower short circuit stresses and damage. This also gives increased flexibility in the speed cone and rolling schedules, but has the disadvantage of losing diversity of rolling loads.

On several hot strip mills now in operation in the United States (Allegheny Ludlum Steel Corp., McLouth Steel Corp., Weirton Steel Co., Republic Steel Corp., and Jones & Laughlin Steel Corp.) the finishing stands are powered individually. The Fairless mill of U. S. Steel has stand motors powered in pairs, and several are arranged for occasional operation with the bus split into two sections.

Luken Steel's new 140-in. plate mill will be the first reversing mill in the Western hemisphere to have a rectifier power supply. Ignitron pumpless rectifiers, back-to-back will supply direct current for 10,000-hp twin-motor main drive and 3000-hp edger.

The installation of static switching controls on two rebuilt blast furnaces increases automation on the charging and skip hoist mechanism. This control replaces the conventional relays, motorized switches, telephone relays, etc., which have been used. Each controller has about 900 static elements to perform the programming and charging of the furnace. Because of the static nature of the control, maintenance should be reduced.

The third blast furnace at the Fairless plant of the U. S. Steel Corp. features very complete automatic control. Although this system does not essentially change the basic functions of existing control processes, it does incorporate a number of improvements over existing systems. These include more simplified operation of the panel board, and an operational check system which automatically isolates and points out failures in the sequence operations of blast furnace charging.

With the increased emphasis on installation of sintering machines, there has been interest in developing electrical control systems for the sintering process. Some of the recent developments are reflected in the new sintering plant being supplied to the U. S. Steel Corp.'s South works at Chicago. One of these controls is aimed at handling the "burn-through point." Changes in the location of this point necessitates changes in the feed rate. However, the change cannot be made instantaneously, since it requires from 10 to 30 min between the time the change is made and the time the result is actually seen in the sintering machine.

Therefore a computer is installed in the control which takes into account the amount of error in the burn-through location, the speed of the conveyor in the sintering machine before the correction is made, and the feed rate of the machine before the correction is made. The computer then decides how much and how fast to change the feed rate.

Also of interest in this plant is the control system which establishes the proportion of each material in the sinter mix. Each of the storage bins is provided with a feeder driven by an adjustable voltage d-c drive. Through this drive system, the exit rate of the material from the bin can be adjusted over a wide range. At the South works plant there are a total of 11 feeders. Each material is fed onto a flexible conveyor riding over a weight scale which measures the flow rate of material out of the bin. A feedback regulator, taking its reference from the burn-through point computer and its feedback from the previously mentioned weigh scales, controls the amount of each material discharged into the mixing conveyor. Automatic switching has been incorporated in a number of these units.

A new development reduces from hours to minutes the time needed for changing tap voltage settings on arc furnace transformers. This control uses switches in a tap-changer control cabinet that eliminate the need for the usual terminal board and linkages for selecting the various tap voltages. This permits altering the voltage simultaneously on all phases, and on any or all taps. With previous controls, it was necessary to shut down for two or three hours to permit the transformer oil to cool, the terminal board cover to be removed from the top of the transformer tank, and the voltage links for each phase to be adjusted under oil with a wrench. The long shutdown time and the possibility of getting contaminants in the oil or into the transformer were a deterrent to making voltage changes that could produce an operating improvement.

The new control operates in conjunction with a standard transformer design which has several secondary voltages which are made available by means of primary winding taps. All of these voltage taps are brought to a motor-operated tap changer which stops only at chosen tap positions. These positions are variable at any time. The control is to be used with a new tap changer mechanism that includes several design advances. Together the units furnish a high degree of freedom from tap switching and voltage problems. Since the tap changer is now mounted separately, it is unlikely that it will ever be necessary to open the main tank transformer.

A hydraulic control on electric arc melting furnaces can be used to increase electrode speeds to over 20 fpm. Basic elements are a jet pipe relay, a four-way booster valve and an actuating cylinder. The piston rod in the cylinder can be connected directly to the electrode mast

(*Please turn to page 188*)

ELECTRIC MOTOR DRIVES THREE HUNDRED HORSEPOWER AND OVER

APPLIED TO ROLLING MILLS IN THE IRON AND STEEL AND ALLIED INDUSTRIES DURING 1957

Item	Horsepower	Revolutions per minute	Volts	Frequency	Method of drive	Type of mill	Purchaser	Location	Manufacturer
1	4 × 300	920	460	d-c	Geared	98-In. hot strip mill edger	Great Lakes Steel Corp., Div. National Steel Corp.	Ecorse, Mich.	Elliott
2	3006	300/1090	250	d-c	Geared	2-High temper pass mill	Universal Cyclops Steel Corp.	Coshocton, Ohio	Elliott
3	300	300/400	250	d-c	Geared	Temper puller	Cia Pacifico	Chile	General Electric
4	300	575/1150	230	d-c	Geared	Non-reversing skin pass mill	Eastern Stainless Steel Corp.	Baltimore, Md.	Reliance
5	300	575/1150	600	d-c	Geared	2-Stand hot mill side trimmer	Olin-Mathieson Chemical Corp.	Omal, Ohio	Westinghouse
6	300	300/750	700	d-c	Geared	Alloy bar mill stand 8	Alpine Montan	Austria	Westinghouse
7	300	350/1050	250	d-c	Geared	Sendzimir mill	Union Carbide Nuclear Co.	Oak Ridge, Tenn.	Westinghouse
8	300	350/1050	230	d-c	Geared	66-In. hot strip mill down-coiler mandrel	Cia Fundidora	Monterrey, Mexico	Westinghouse
9	300	250/500	250	d-c	Geared	Skin pass mill	Cia Fundidora	Monterrey, Mexico	Westinghouse
10	300	300/900	250	d-c	Geared	Skin pass mill	Cia Fundidora	Monterrey, Mexico	Westinghouse
11	300	300/900	250	d-c	Geared	Hot strip mill coiler	Armco Steel Corp.	Butler, Pa.	Westinghouse
12	300	300/900	250	d-c	Geared	Hot strip mill coiler	Armco Steel Corp.	Butler, Pa.	Westinghouse
13	300	375/1050	250	d-c	Geared	Hot strip mill coiler	Armco Steel Corp.	Middletown, Ohio	Westinghouse
14	300	375/1050	250	d-c	Geared	Hot strip mill coiler	Armco Steel Corp.	Middletown, Ohio	Westinghouse
15	300	375/1050	250	d-c	Geared	Hot strip mill coiler	Armco Steel Corp.	Middletown, Ohio	Westinghouse
16	350	500/1000	250	d-c	Geared	2-High temper pass mill	Universal Cyclops Steel Corp.	Coshocton, Ohio	Elliott
17	350	575/1150	600	d-c	Direct	Temper mill	Cia Pacifico	Chile	General Electric
18	350	575/1150	600	d-c	Direct	Temper mill	Cia Pacifico	Chile	General Electric
19	350	300/800	600	d-c	Geared	Merchant & bar mill	Bethlehem Pacific Coast Steel Corp.	Seattle, Wash.	Westinghouse
20	350	280/875	750	d-c	Direct	Reel on skin pass mill	Youngstown Sheet & Tube Co.	Youngstown, Ohio	Westinghouse
21	350	575/850	250	d-c	Geared	Scalebreaker	Inland Steel Co.	Indiana Harbor, Ind.	Westinghouse
22	350	575/850	250	d-c	Geared	Scalebreaker	Inland Steel Co.	Indiana Harbor, Ind.	Westinghouse
23	375	360	230	d-c	Geared	Slab shear	Algoma Steel Corp.	Sault Ste. Marie, Can.	Westinghouse
24	375	360	230	d-c	Geared	Slab shear	Algoma Steel Corp.	Sault Ste. Marie, Can.	Westinghouse
25	375	360	250	d-c	Geared	Scalebreaker	Wheeling Steel Corp.	Yorkville, Ohio	Westinghouse
26	400*	720	4160	60	Geared	Rod mill	Essex Wire Corp.	Jonesboro, Ind.	Allis-Chalmers
27	400*	720	4160	60	Geared	Rod mill	Essex Wire Corp.	Jonesboro, Ind.	Allis-Chalmers
28	400*	360	4160	60	Direct	Rod mill	Essex Wire Corp.	Jonesboro, Ind.	Allis-Chalmers
29	400	300/900	600	d-c	Geared	8-Stand billet mill edger	Somisa	Argentina	General Electric
30	400	400/1200	250	d-c	Direct	4-High non-reversing cold mill	Harrison Radiator Co.	Lockport, N. Y.	General Electric
31	400	400/1200	600	d-c	Geared	2-Stand hot mill tension reel	Olin-Mathieson Chemical Corp.	Omal, Ohio	Westinghouse
32	400	500/1250	600	d-c	Geared	48-In. foil mill	Aluminum Co. of Canada	Brazil	Westinghouse
33	400	690/1380	250	d-c	Geared	Wheel mill edger	Canadian Steel Wheel, Ltd.	Montreal, Canada	General Electric
34	500*	720	4160	60	Geared	Rod mill	Essex Wire Corp.	Jonesboro, Ind.	Allis-Chalmers
35	500	300/1100	600	d-c	Geared	4-High reversing cold mill	Universal Cyclops Steel Corp.	Coshocton, Ohio	Elliott
36	500	300/1100	600	d-c	Geared	4-High reversing cold mill	Universal Cyclops Steel Corp.	Coshocton, Ohio	Elliott
37	500	400/900	600	d-c	Geared	Merchant & bar mill	Bethlehem Pacific Coast Steel Corp.	Seattle, Wash.	Westinghouse
38	500	200/500	700	d-c	Geared	Roughing stand 1, hot strip and merchant bar mill	Alpine Montan	Austria	Westinghouse
39	500	340/1040	700	d-c	Geared	Rod mill	Armco Steel Corp., Sheffield Steel Div.	Kansas City, Mo.	Westinghouse
40	500	340/1040	700	d-c	Geared	Rod mill	Armco Steel Corp., Sheffield Steel Div.	Kansas City, Mo.	Westinghouse
41	500	340/1040	700	d-c	Geared	Rod mill	Armco Steel Corp., Sheffield Steel Div.	Kansas City, Mo.	Westinghouse
42	500	340/1040	700	d-c	Geared	Rod mill	Armco Steel Corp., Sheffield Steel Div.	Kansas City, Mo.	Westinghouse
43	500	150/375	600	d-c	Direct	Merchant mill	Atlas Steels, Ltd.	Welland, Ont.	Westinghouse
44	500	300/900	600	d-c	Geared	Temper pass mill reel	U. S. Steel Corp.	Gary, Ind.	Westinghouse
45	500	340	250	d-c	Geared	Shear	U. S. Steel Corp.	S. Chicago, Ill.	Westinghouse
46	600	690/1380	375	d-c	Geared	Continuous seamless tube mill	The Babcock & Wilcox Co.	Milwaukee, Wisc.	Allis-Chalmers
47	600	690/1380	375	d-c	Geared	Continuous seamless tube mill	The Babcock & Wilcox Co.	Milwaukee, Wisc.	Allis-Chalmers
48	600*	900	2300	60	Geared	Merchant mill	H. K. Porter Co.	Huntington, W. Va.	Allis-Chalmers
49	600*	900	2300	60	Geared	Merchant mill	H. K. Porter Co.	Huntington, W. Va.	Allis-Chalmers
50	600	200/600	600	d-c	Geared	Reversing rougher-edger	Cia Fundidora	Mexico	General Electric
51	600	400/800	600	d-c	Geared	Merchant & bar mill	Bethlehem Pacific Coast Steel Corp.	Seattle, Wash.	Westinghouse
52	600	400/1200	600	d-c	Geared	Merchant & bar mill	Bethlehem Pacific Coast Steel Corp.	Seattle, Wash.	Westinghouse
53	600	375/750	700	d-c	Geared	Alloy bar mill stand 3	Alpine Montan	Austria	Westinghouse
54	600	350/990	700	d-c	Geared	Alloy bar mill stand 6 & 7	Alpine Montan	Austria	Westinghouse
55	600	350/1050	700	d-c	Geared	Alloy bar mill stand 9-10-11	Alpine Montan	Austria	Westinghouse
56	600	300/900	700	d-c	Geared	Rod mill stand 2 & 3	Alpine Montan	Austria	Westinghouse
57	600	300/900	700	d-c	Geared	Rod mill stand 4 & 5	Alpine Montan	Austria	Westinghouse
58	600	300/900	700	d-c	Geared	Rod mill stand 6 & 7	Alpine Montan	Austria	Westinghouse
59	600	300/900	700	d-c	Geared	Rod mill stand 8 & 9	Alpine Montan	Austria	Westinghouse
60	600	400/1060	700	d-c	Geared	Rod mill	Armco Steel Corp., Sheffield Steel Div.	Kansas City, Mo.	Westinghouse
61	600	400/1060	700	d-c	Geared	Rod mill	Armco Steel Corp., Sheffield Steel Div.	Kansas City, Mo.	Westinghouse
62	600	400/1060	700	d-c	Geared	Rod mill	Armco Steel Corp., Sheffield Steel Div.	Kansas City, Mo.	Westinghouse
63	600	400/1060	700	d-c	Geared	Rod mill	Armco Steel Corp., Sheffield Steel Div.	Kansas City, Mo.	Westinghouse
64	600	400/1060	700	d-c	Geared	Rod mill	Armco Steel Corp., Sheffield Steel Div.	Kansas City, Mo.	Westinghouse
65	600	225/675	700	d-c	Direct	Rod mill	Armco Steel Corp., Sheffield Steel Div.	Kansas City, Mo.	Westinghouse
66	600ⓘ	200/600	600	d-c	Geared	46-In. combination mill edger	Algoma Steel Corp.	Sault Ste. Marie, Can.	Westinghouse
67	600ⓘ	200/600	600	d-c	Geared	46-In. combination mill edger	Algoma Steel Corp.	Sault Ste. Marie, Can.	Westinghouse
68	700	200/800	600	d-c	Geared	3-Stand tandem cold mill reel	Cia Pacifico	Chile	General Electric
69	700	200/800	600	d-c	Geared	Temper mill reel	Cia Pacifico	Chile	General Electric
70	700	300/750	600	d-c	Geared	8-Stand billet mill, stand 1	Somisa	Argentina	General Electric
71	700	300/750	600	d-c	Geared	8-Stand billet mill, stand 2	Somisa	Argentina	General Electric
72	700	300/750	600	d-c	Geared	8-Stand billet mill, stand 3	Somisa	Argentina	General Electric
73	700	300/900	700	d-c	Geared	Rod mill stand 10 & 11	Alpine Montan	Austria	Westinghouse
74	700	690/1270	700	d-c	Geared	Rod mill stand 16 & 17	Alpine Montan	Austria	Westinghouse
75	700	690/1270	700	d-c	Geared	Rod mill stand 18 & 19	Alpine Montan	Austria	Westinghouse
76	700	690/1270	700	d-c	Geared	Rod mill stand 20 & 21	Alpine Montan	Austria	Westinghouse
77	700	690/1270	700	d-c	Geared	Rod mill stand 22 & 23	Alpine Montan	Austria	Westinghouse
78	700	690/1270	700	d-c	Geared	Rod mill stand 24 & 25	Alpine Montan	Austria	Westinghouse
79	700	690/1270	700	d-c	Geared	Rod mill stand 26 & 27	Alpine Montan	Austria	Westinghouse
80	700	690/1270	700	d-c	Geared	Rod mill stand 28 & 29	Alpine Montan	Austria	Westinghouse
81	700	690/1270	700	d-c	Geared	Rod mill stand 30 & 31	Alpine Montan	Austria	Westinghouse
82	700	300/900	700	d-c	Geared	Merchant bar mill, stand 16 & 17	Alpine Montan	Austria	Westinghouse
83	700	400/1010	700	d-c	Geared	Rod mill	Armco Steel Corp., Sheffield Steel Div.	Kansas City, Mo.	Westinghouse
84	700	200/600	700	d-c	Direct	Rod mill	Armco Steel Corp., Sheffield Steel Div.	Kansas City, Mo.	Westinghouse
85	700	690/1270	600	d-c	Geared	Temper mill	U. S. Steel Corp.	Gary, Ind.	Westinghouse
86	750	200/700	600	d-c	Geared	Reversing cold strip mill	Altos Hornos	Mexico	General Electric
87	750	200/700	600	d-c	Geared	Reversing cold strip mill	Altos Hornos	Mexico	General Electric
88	800	300/600	600	d-c	Geared	8-Stand billet mill, stand 6	Somisa	Argentina	General Electric
89	800	300/600	600	d-c	Geared	8-Stand billet mill, stand 7	Somisa	Argentina	General Electric
90	800	400/800	600	d-c	Geared	8-Stand billet mill, stand 4	Somisa	Argentina	General Electric
91	800	400/800	600	d-c	Geared	8-Stand billet mill, stand 5	Somisa	Argentina	General Electric
92	800	400/800	600	d-c	Geared	8-Stand billet mill, stand 8	Somisa	Argentina	General Electric
93	800†	375	2300	50	Geared	Hot strip mill scalebreaker	Somisa	Argentina	Westinghouse
94	800	500/1000	700	d-c	Geared	Alloy bar mill, stand 4 & 5	Alpine Montan	Austria	Westinghouse
95	800	250/625	700	d-c	Geared	Roughing stand 2 & 3, hot strip and merchant bar mill	Alpine Montan	Austria	Westinghouse
96	800	300/750	700	d-c	Geared	Roughing stand 4 & 5, hot strip and merchant bar mill	Alpine Montan	Austria	Westinghouse
97	800*	720	2300	60	Direct	Piercing mill	Scovill Mfg. Co.	Waterbury, Conn.	Westinghouse

ELECTRIC MOTOR DRIVES THREE HUNDRED HORSEPOWER AND OVER (CONTINUED)

Item	Horsepower	Revolutions per minute	Volts	Frequency	Method of drive	Type of mill	Purchaser	Location	Manufacturer
98	800(600kw)	300/900	600	d-c	Geared	56-In. reversing cold mill payoff reel	Dominion Foundries & Steel, Ltd.	Hamilton, Ontario, Can.	Westinghouse
99	900	300/900	600	d-c	Geared	Merchant & bar mill	Bethlehem Pacific Coast Steel Corp.	Seattle, Wash.	Westinghouse
100	900/450*	300/150	4160	60	Geared	16-In. bar mill	Compania Antillana De Acero	Cuba	Westinghouse
101	900	350/750	700	d-c	Geared	Rod mill stand 12 & 13	Alpine Montan	Austria	Westinghouse
102	900	350/750	700	d-c	Geared	Rod mill stand 14 & 15	Alpine Montan	Austria	Westinghouse
103	1000*	900	2300	60	Geared	Merchant mill	H. K. Porter Co.	Huntington, W. Va.	Allis-Chalmers
104	1000	250/600	600	d-c	Direct	37-In. sendzimir mill	American Steel & Wire Div., U. S. Steel Corp.	Cleveland, Ohio	Allis-Chalmers
105	1000	250/750	600	d-c	Geared	37-In. sendzimir mill	American Steel & Wire Div., U. S. Steel Corp.	Cleveland, Ohio	Allis-Chalmers
106	1000	250/750	600	d-c	Geared	37-In. sendzimir mill	American Steel & Wire Div., U. S. Steel Corp.	Cleveland, Ohio	Allis-Chalmers
107	1000	300/750	600	d-c	Geared	Rod & merchant mill, stand 9	Armco Steel Corp., Sheffield Steel Div.	Kansas City, Mo.	General Electric
108	1000*	400	4000	60	Geared	Reversing rougher-scalebreaker	Cia Fundidora	Mexico	General Electric
109	1000	350/875	700	d-c	Geared	Roughing stand 6 & 7 hot strip and merchant bar mill	Alpine Montan	Austria	Westinghouse
110	1000	300/750	700	d-c	Geared	Roughing stand 8 & 9, hot strip and merchant bar mill	Alpine Montan	Austria	Westinghouse
111	1000	300/600	700	d-c	Geared	Merchant bar mill, stand 19	Alpine Montan	Austria	Westinghouse
112	1000	300/780	700	d-c	Geared	Rod mill	Armco Steel Corp., Sheffield Steel Div.	Kansas City, Mo.	Westinghouse
113	1000	300/900	600	d-c	Geared	Non-reversing cold mill	Anaconda American Brass, Ltd.	Toronto, Canada	General Electric
114	1000	300/780	700	d-c	Geared	Rod mill	Armco Steel Corp., Sheffield Steel Div.	Kansas City, Mo.	Westinghouse
115	1000	200/675	600	d-c	Geared	Reversing cold mill reel	Cia Fundidora	Monterrey, Mexico	Westinghouse
116	1000	200/675	600	d-c	Geared	Reversing cold mill reel	Cia Fundidora	Monterrey, Mexico	Westinghouse
117	1200	150/525	600	d-c	Direct	Skin pass mill	Cia Fundidora	Monterrey, Mexico	Westinghouse
118	1250	250/750	600	d-c	Geared	4-High reversing cold mill	Universal Cyclops Steel Corp.	Coshocton, Ohio	Elliott
119	1250	250/660	600	d-c	Geared	Merchant & bar mill	Bethlehem Pacific Coast Steel Corp.	Seattle, Wash.	Westinghouse
120	1250	200/600	700	d-c	Geared	Merchant bar mill, stand 18	Alpine Montan	Austria	Westinghouse
121	1250	500/920	700	d-c	Geared	Rod mill	Armco Steel Corp., Sheffield Steel Div.	Kansas City, Mo.	Westinghouse
122	1250	500/920	700	d-c	Geared	Rod mill	Armco Steel Corp., Sheffield Steel Div.	Kansas City, Mo.	Westinghouse
123	1250	200/600	700	d-c	Geared	Merchant bar mill, stand 14 & 15	Alpine Montan	Austria	Westinghouse
124	1500	300/600	600	d-c	Geared	Billet mill, stand 1	U. S. Steel Corp.	Duquesne, Pa.	Elliott
125	1500	300/600	600	d-c	Geared	Billet mill, stand 2	U. S. Steel Corp.	Duquesne, Pa.	Elliott
126	1500	300/600	600	d-c	Geared	Billet mill, stand 3	U. S. Steel Corp.	Duquesne, Pa.	Elliott
127	1500	300/600	600	d-c	Geared	Billet mill, stand 4	U. S. Steel Corp.	Duquesne, Pa.	Elliott
128	1500	80/180	700	d-c	Geared	Rail & structural finishing stand	Companhia Siderurgica Nacional	Volta Redonda, Brazil	General Electric
129	1500	80/180	700	d-c	Geared	3-Stand tandem cold mill stand 1	Cia Pacifico	Chile	General Electric
130	1500†	720	4160	60	Geared	28-In. blooming & billet mill	Compania Antillana De Acero	Cuba	Westinghouse
131	1500†	720	4160	60	Geared	16-In. bar mill	Compania Antillana De Acero	Cuba	Westinghouse
132	1500	375/750	700	d-c	Geared	Alloy bar mill, stand 1 & 2	Alpine Montan	Austria	Westinghouse
133	1500	300/750	700	d-c	Geared	Hot strip mill, finishing stand 1	Alpine Montan	Austria	Westinghouse
134	1500	300/750	700	d-c	Geared	Hot strip mill, finishing stand 2	Alpine Montan	Austria	Westinghouse
135	1500	300/750	700	d-c	Geared	Hot strip mill, finishing stand 3	Alpine Montan	Austria	Westinghouse
136	1500	150/375	700	d-c	Geared	Hot strip mill, finishing stand 4	Alpine Montan	Austria	Westinghouse
137	1500	200/500	700	d-c	Geared	Hot strip mill, finishing stand 5	Alpine Montan	Austria	Westinghouse
138	1500	225/565	700	d-c	Geared	Hot strip mill, finishing stand 6	Alpine Montan	Austria	Westinghouse
139	1500	300/750	700	d-c	Geared	Merchant bar mill, stand 10 & 11	Alpine Montan	Austria	Westinghouse
140	1500	150/450	600	d-c	Geared	110-In. plate mill edger	Steel Co. of Canada	Hamilton, Ontario, Canada	Westinghouse
141	1500	350/700	600	d-c	Geared	72-In. reversing hot mill	Anaconda American Brass	Toronto, Ontario, Canada	Westinghouse
142	1500	250/360	600	d-c	Direct	Skin pass mill	Cia Fundidora	Monterrey, Mexico	Westinghouse
143	1750	250/625	700	d-c	Geared	3-Stand tandem cold mill, stand 2	Cia Pacifico	Chile	General Electric
144	1750	250/625	700	d-c	Geared	3-Stand tandem cold mill, stand 3	Cia Pacifico	Chile	General Electric
145	1750	300/600	600	d-c	Geared	56-In. reversing cold mill	Steel Co. of Canada, Ltd.	Hamilton, Ontario, Canada	Westinghouse
146	1750	300/600	600	d-c	Geared	56-In. reversing cold mill	Steel Co. of Canada, Ltd.	Hamilton, Ontario, Canada	Westinghouse
147	1750	150/450	700	d-c	Geared	Merchant bar mill stand 12 & 13	Alpine Montan	Austria	Westinghouse
148	2000	175/350	600	d-c	Geared	Reversing cold strip mill	Altos Hornos	Mexico	General Electric
149	2000	200/400	600	d-c	Geared	170-In. slabbing mill edger	Reynolds Metals Co.	Listerhill, Ala.	Westinghouse
150	2000	200/720	600	d-c	Geared	56-In. reversing cold mill reel	Steel Co. of Canada, Ltd.	Hamilton, Ontario, Canada	Westinghouse
151	2000	200/720	600	d-c	Geared	56-In. reversing cold mill reel	Steel Co. of Canada, Ltd.	Hamilton, Ontario, Canada	Westinghouse
152	2000	100/300	650	d-c	Geared	Slabbing mill edger	Dominion Foundries & Steel Ltd.	Hamilton, Ontario, Canada	Westinghouse
153	2000*	514	4000	60	Geared	Billet mill	Cia Fundidora	Monterrey, Mexico	Westinghouse
154	2000*	514	4000	60	Geared	Billet mill	Cia Fundidora	Monterrey, Mexico	Westinghouse
155	2170	217/542	650	d-c	Geared	56-In. reversing cold mill	Dominion Foundries & Steel, Ltd.	Hamilton, Ontario, Canada	Westinghouse
156	2170	217/542	650	d-c	Geared	56-In. reversing cold mill	Dominion Foundries & Steel, Ltd.	Hamilton, Ontario, Canada	Westinghouse
157	2170	244/732	650	d-c	Geared	56-In. reversing cold mill reel	Dominion Foundries & Steel, Ltd.	Hamilton, Ontario, Canada	Westinghouse
158	2170	244/732	650	d-c	Geared	56-In. reversing cold mill reel	Dominion Foundries & Steel, Ltd.	Hamilton, Ontario, Canada	Westinghouse
159	2500	250/500	750	d-c	Geared	Hot strip mill, stand 6	Companhia Siderurgica Nacional	Volta Redonda, Brazil	General Electric
160	3000①	60/150	750	d-c	Direct	36-In. blooming mill	U. S. Steel Corp.	Duquesne, Pa.	General Electric
161	3000①	60/150	750	d-c	Direct	36-In. blooming mill	U. S. Steel Corp.	Duquesne, Pa.	General Electric
162	3000	70/175	750	d-c	Geared	Reversing plate mill edger	Lukens Steel Co.	Coatesville, Pa.	General Electric
163	3000	175/350	600	d-c	Direct	Reversing cold mill	Cia Fundidora	Monterrey, Mexico	Westinghouse
164	3500①	40/100	750	d-c	Geared	Reversing rougher	Cia Fundidora	Monterrey, Mexico	General Electric
165	3500①	40/100	750	d-c	Geared	Reversing rougher	Cia Fundidora	Monterrey, Mexico	General Electric
166	3500①	40/100	750	d-c	Geared	Blooming mill	Cia Fundidora	Monterrey, Mexico	General Electric
167	3500①	40/100	750	d-c	Geared	Blooming mill	Cia Fundidora	Monterrey, Mexico	General Electric
168	3500	150/336	700	d-c	Geared	Hot strip mill, finishing stand 5	Somisa	Argentina	Westinghouse
169	3500	150/336	700	d-c	Direct	Hot strip mill, finishing stand 10	Somisa	Argentina	Westinghouse
170	3500①	50/120	700	d-c	Direct	45-In. blooming & slabbing mill	Somisa	Argentina	Westinghouse
171	3500①	50/120	700	d-c	Direct	45-In. blooming & slabbing mill	Somisa	Argentina	Westinghouse
172	4000*	500	13800	50	Geared	Hot strip mill, roughing stand 1	Somisa	Argentina	Westinghouse
173	4000*	500	13800	50	Geared	Hot strip mill, roughing stand 2	Somisa	Argentina	Westinghouse
174	4000*	500	13800	50	Geared	Hot strip mill, roughing stand 3	Somisa	Argentina	Westinghouse
175	4000*	500	13800	50	Geared	Hot strip mill, roughing stand 4	Somisa	Argentina	Westinghouse
176	4000	145/290	700	d-c	Geared	Hot strip mill, finishing stand 6	Somisa	Argentina	Westinghouse
177	4000	145/290	700	d-c	Geared	Hot strip mill, finishing stand 7	Somisa	Argentina	Westinghouse
178	4000	110/220	700	d-c	Direct	Hot strip mill, finishing stand 8	Somisa	Argentina	Westinghouse
179	4000	145/290	700	d-c	Direct	Hot strip mill, finishing stand 9	Somisa	Argentina	Westinghouse
180	4000	50/120	700	d-c	Direct	Rail & structural mill	Somisa	Argentina	Westinghouse
181	4000①	50/120	700	d-c	Direct	44-In. blooming mill	Venezuelan Steel Mill	Venezuela	Westinghouse
182	4000①	50/120	700	d-c	Direct	44-In. blooming mill	Venezuelan Steel Mill	Venezuela	Westinghouse
183	4000	60/150	700	d-c	Direct	32-In. blooming mill	Bethlehem Pacific Coast Steel Corp.	Seattle, Wash.	Westinghouse
184	4000①	40/80	700	d-c	Direct	46-In. combination mill	Algoma Steel Corp.	Sault Ste. Marie, Can.	Westinghouse
185	4000①	40/80	700	d-c	Direct	46-In. combination mill	Algoma Steel Corp.	Sault Ste. Marie, Can.	Westinghouse
186	4000	150/336	700	d-c	Geared	66-In. hot strip mill, finishing stand 2	Cia Fundidora	Monterrey, Mexico	Westinghouse
187	4000	150/300	700	d-c	Geared	66-In. hot strip mill, finishing stand 3	Cia Fundidora	Monterrey, Mexico	Westinghouse
188	4000	110/220	700	d-c	Direct	66-In. hot strip mill, finishing stand 4	Cia Fundidora	Monterrey, Mexico	Westinghouse
189	4000	135/270	700	d-c	Direct	66-In. hot strip mill, finishing stand 5	Cia Fundidora	Monterrey, Mexico	Westinghouse
190	4000	250/420	600	d-c	Geared	66-In. hot strip finishing stand	Ford Motor Co.	Detroit, Mich.	Allis-Chalmers
191	5000①	40/80	750	d-c	Direct	Reversing plate mill	Lukens Steel Co.	Coatesville, Pa.	General Electric
192	5000①	40/80	750	d-c	Direct	Reversing plate mill	Lukens Steel Co.	Coatesville, Pa.	General Electric
193	5000①	40/80	750	d-c	Direct	46-In. blooming mill	U. S. Steel Corp.	Duquesne, Pa.	General Electric
194	5000①	40/100	750	d-c	Direct	46-In. blooming mill	U. S. Steel Corp.	Duquesne, Pa.	General Electric
195	5000	35/90	650	d-c	Direct	Universal slabbing mill	Dominion Foundries & Steel, Ltd.	Hamilton, Ontario, Canada	Westinghouse
196	6000①②	50/120	750	d-c	Direct	44-In. blooming mill	Youngstown Sheet & Tube Co.	Youngstown, Ohio	General Electric
197	6000①②	50/120	750	d-c	Direct	44-In. blooming mill	Youngstown Sheet & Tube Co.	Youngstown, Ohio	General Electric
198	6000	80/160	750	d-c	Direct	32-In. reversing billet mill	Tata Iron & Steel Co., Ltd.	Jamshedpur, India	General Electric

* Synchronous motors. ① Twin motor drive. ② Triple armature. ⑤ Denotes AISE Mill Motor frame when used.
† Induction motor. ③ Double armature. ④ One-half double armature. ⑥ Four 300-hp motors connected together.

MOTOR RECAPITULATION

Company	*Location*	*Type of mill*	*Number of motors*	*Total horsepower*
Algoma Steel Corp.	Sault Ste. Marie, Can.	46-In. combination mill slab shears	2	8,000
			2	750
		Combination mill edger	2	1,200
Altos Hornos	Montclova, Mexico	Reversing cold strip mill	3	3,500
Alpine Montan	Austria	Alloy bar mill	6	4,400
		Rod mill	15	10,500
		Roughing stands—Strip and merchant bar mill	5	4,100
		Hot strip mill finishing stands	6	9,000
		Merchant bar finishing stands	6	7,450
Anaconda American Brass Co.	Toronto, Ontario	Reversing hot mill	1	1,500
		Non-reversing cold mill	1	1,000
Atlas Steels, Ltd.	Welland, Ontario	Merchant mill	1	500
Aluminum Co. of Canada	Brazil	48-In. foil mill	1	400
Armco Steel Corp.				
Sheffield Steel Div.	Butler, Pa.	Hot strip mill coilers	2	600
	Middletown, Ohio	Hot strip mill coilers	3	900
	Kansas City, Mo.	Rod mill	16	11,500
		Rod and merchant mill	1	1,000
Babcock & Wilcox Co.	Milwaukee, Wisc.	Continuous seamless tube mill	2	1,200
Bethlehem Pacific Coast Steel Corp.	Seattle, Wash.	Merchant and bar mill	6	4,200
		Blooming mill	1	4,000
Cia Fundidora de Fierro y Acero de Monterrey	Monterrey, Mexico	Hot strip mill	9	24,900
		66-In. reversing cold mill	3	5,000
		Skin pass mill	4	3,300
		Billet mill	2	4,000
		Blooming mill	2	7,000
Canadian Steel Wheel, Ltd.	Montreal, Can.	Wheel mill edger	1	400
Cia Pacifico	Chile	Temper mill	4	1,700
		3-Stand tandem cold mill	4	5,700
Compania Antillana De Acero	Cuba	28-In. blooming and billet mill	1	1,500
		16-In. bar mill	2	2,400
Companhia Siderurgica Nacional	Volta Redonda, Brazil	Rail and structural finishing stand	1	1,500
		Hot strip mill, stand no. 6	1	2,500
Dominion Foundries & Steel Ltd.	Hamilton, Ontario	56-In. reversing cold mill	5	9,480
		Universal slabbing mill	2	7,000
Eastern Stainless Steel Corp.	Baltimore, Md.	Non-reversing skin pass mill	1	300
Essex Wire Corp.	Jonesboro, Ind.	Rod mill	4	1,700
Ford Motor Co.	Detroit, Mich.	Hot strip finishing mill	1	4,000
Great Lakes Steel Corp. (Div. National Steel Corp.)	Ecorse, Mich.	Hot strip mill edger	1	1,200
			(Four motors coupled together)	
Harrison Radiator Co.	Lockport, N. Y.	4-High non-reversing cold mill	1	400
Inland Steel Co.	Indiana Harbor, Ind.	Scalebreaker	2	700
Lukens Steel Co.	Coatesville, Pa.	Reversing plate mill	3	13,000
Olin-Mathieson Chemical Corp.	Omal, Ohio	Hot mill side trimmer	1	300
		Hot mill tension reel	1	400
H. K. Porter Co., Connors Steel Div.	Huntington, W. Va.	Merchant mill	3	2,200
Somisa	Argentina	8 Stand billet edger	9	6,500
		Hot strip mill	11	39,800
		Rail and structural mill	1	4,000
		Blooming and slabbing mill	2	7,000
Reynolds Metals Co.	Listerhill, Ala.	Slabbing mill edger	1	2,000
Scovill Mfg. Co.	Waterbury, Conn.	Piercing mill	1	800
Steel Co. of Canada, Ltd.	Hamilton, Ontario	Reversing cold mill	4	7,500
		110-In. plate mill edger	1	1,500
Tata Iron & Steel Co.	Jamshedpur, India	32-In. reversing billet mill	1	6,000
Union Carbide Nuclear Co.	Oak Ridge, Tenn.	Sendzimir mill	1	300
Universal Cyclops Steel Corp.	Coshocton, Ohio	2-High temper pass mill	2	650
		4-High reversing cold mill	3	2,250
U. S. Steel Corp.	Duquesne, Pa.	46-In. blooming mill	2	10,000
		36-In. blooming mill	2	6,000
		Billet mill	4	6,000
	Gary, Ind.	Temper pass mill	2	1,200
	South Chicago, Ill.	Shear	1	500
American Steel & Wire Div.	Cleveland, Ohio	37-In. Sendzimir mill	3	3,000
Venezuelan Steel Mill	Venezuela	Blooming mill	2	8,000
Wheeling Steel Corp.	Yorkville, Ohio	Scalebreaker	1	375
Youngstown Sheet & Tube Co.	Youngstown, Ohio	Skin pass mill reel	1	350
		44-In. blooming mill	2	12,000

Types of motors purchased	*Number of motors*	*Total horsepower*
Alternating-current motors	19	30,400
Direct-current motors	179	271,605
	198	302,005

(*Continued from page 185*)

and is positioned in accordance with electrical signals representative of arc voltage and current. Because of the low inertia of the hydraulic system, acceleration and deceleration are practically instantaneous, and the electrodes can be lowered at maximum speed toward the melt, and yet be decelerated at a fast enough rate to prevent damage to the electrode.

Results of an experimental program on the use of hollow electrodes in electric arc furnaces indicate that such electrodes will give a steadier arc, faster melting and lower power requirements, but apparently with higher electrode consumption. Further trials are necessary to clarify the picture.

An interesting piece of equipment for determining the location of electrodes in the arc furnace was patented during the year. In this equipment an electrical or ultrasonic impulse is transmitted from the upper end of the electrode to the bottom end within the charge. It receives a reflected impulse, establishes the elapsed time, and varies the depth of the electrode within the charge until the elapsed time reaches a predetermined value.

To reduce light flicker, a southern steel mill installed a new type synchronous condenser rated 30,000 kva (leading) at ½-psi hydrogen pressure, 25,000 kva (lagging), 13,800-v, 3-phase, 60 cycle, 3600-rpm. At 10-psi hydrogen, unit is capable of 40,000 kva (leading).

The AISE gave final approval to a new 600 series mill motor standard in 1957 and the standard was published in the November 1957 Iron and Steel Engineer. This covers new d-c mill motor ratings of 275, 375 and 500 hp, expanding the previous standard which went up only to 200 hp. These motors differ somewhat from the regular line in that the standard motor frames are applicable for coupled service only, and are not available with back axles. They are not

furnished for 550 volts. A number of these motors are already in service and on order for steel plant applications.

The AISE also adopted a new d-c mill motor brake standard, published in the October, 1957, Iron and Steel Engineer. This standard is basically a revision of the older standard in order to set up brake standards for the new 275, 375, and 500-hp, d-c mill motors added to the motor standard. These brakes, which make all manufacturers' brakes interchangeable with respect to mounting dimensions, torque ratings and wheel dimensions, were developed in conjunction with the control committee of NEMA.

Eddy-current adjustable drives offer possibilities for use in the steel industry. In eddy-current couplings, the speed and torque are regulated by a control which varies the current in a single field coil per section. The advantages are low initial cost, compact floor space, simple construction, low maintenance and operating cost. Such couplings can be built in sizes from one to 20,000 hp.

A new kind of magnetic steel announced during the year is described as a doubly oriented silicon iron or cube-oriented silicon iron. It will be used in magnetic cores of electrical devices such as transformers, motors and other equipment. The basic characteristic of the new steel is that the crystal orientation is such that the material can be magnetized in four directions, in comparison to the conventional magnetic steels which can be magnetized in only two directions.

A unit, called a push-to-test indicating light unit, provides a quick, positive method of testing for burned out lamp bulbs on control panels and push button stations. This is accomplished through the use of a continuously energized testing circuit which gives an immediate indication of a faulty bulb by pressing the unit's color cap. It is not necessary to remove the indicating light cap or the bulb.

An atomic-powered battery has been developed which is no bigger than a cough drop and yet is capable of delivering usable electricity for at least five years. This battery uses beta rays from a radioisotope which are converted to light, and the light is then converted to electricity. Phenomena is a physical reaction between tiny silicon photocells and phosphor materials. The battery would be used in transistorized radios, hearing aids and even electric wristwatches. It is not yet commercially available.

A significant step towards the direct conversion of heat energy into electrical energy is an electronic device known as thermionic converter. So far the device has no commercial applications. It takes advantage of the principle that under some conditions, electrons can be boiled out of a hot metal surface and used directly to produce an electric current. Experimental converters have changed more than eight per cent of applied heat energy to electric power and the research people are aiming at 30 per cent conversion efficiency. The basic trick is to smooth the path of the electrons between a hot electrode which emits electrons and a colder (although still red hot) electrode set up to collect them.

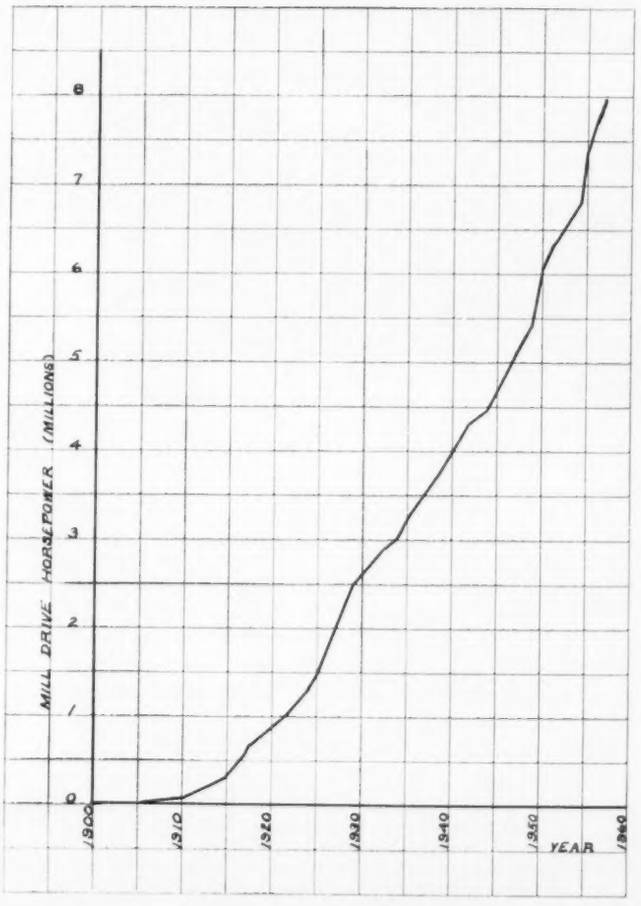
A new device for electronic circuits is called a "solion." This differs from transistors and vacuum tubes in the method in which the electrical charge is transported. In conventional devices, the electrons are the charge carriers, operating in a vacuum in the tube, and in a solid in the transistor. In devices using solion, ions in solution carry the charge.

Electrochemical devices which perform useful circuit functions have been experimented with for some 15 years. The solion's sensitive reaction to low-energy stimuli and the extremely low power required for its operation makes it particularly attractive in remote and unattended devices. It is expected that it will find wide use in process controls, analog computers, data processing equipment and similar applications.

Since the current carriers are ions instead of electrons, the frequency response is limited because of the high ratio of ion to electron mass. The solion usually operates best in a range from a small fraction of a cycle per second to ten or twenty cycles per second.

Sales of main drives during the year reflected the completion of the current steel plant expansion program in the United States and were well under last year's total of 474,860 hp. The horsepower of main drives sold in 1957 totaled 302,005 hp from 198 motors, largely for foreign mills. Of these motors, 19 were alternating current, and 179 were direct current. Accumulative curve of main drive motors over 300 hp show a total as of January 1, 1958, of 7,981,019 hp.

Accumulative curve of main drives over 300 hp show a total as of January 1, 1958, of 7,981,019 hp. One hundred and ninety-eight motors (302,005 hp) were added in 1957, of which 179 were direct-current and 19 were alternating-current.



New RUST UPSETTER FURNACE takes 3½" to 10¾" pipe

Upsetter Furnace at Seamless Specialty Mill, Jones & Laughlin Steel Corp., Aliquippa, Pa.

Jets of water prevent spread of heat from white hot ends of pipe.

A new slot type Upsetter Furnace for heating pipe ends prior to upset forging was especially designed and constructed by Rust Furnace Company for Jones & Laughlin Steel Corporation's Aliquippa seamless tube mill. It is the first upset furnace of its type and handles a variety of sizes of seamless tubing from 3½" to 10¾" in diameter. The pipe is used for deep wells.

Rust Furnace Company, serving the metallurgical industry since 1925, designs, constructs and places in operation all types of furnaces. The Company is equipped to meet any of your needs in the melting, reheating, or heat treating fields.

THE WHOLE JOB IS ONE JOB WITH A "RUST PACKAGE CONTRACT"

One contract covers everything, from original idea to start-up. One responsibility for design, manufacture, erection and initial operation. One overhead and profit (with substantial savings to you) on all phases of the work, including wiring and piping.

Rust Furnace Company

Pioneers in Furnace Design

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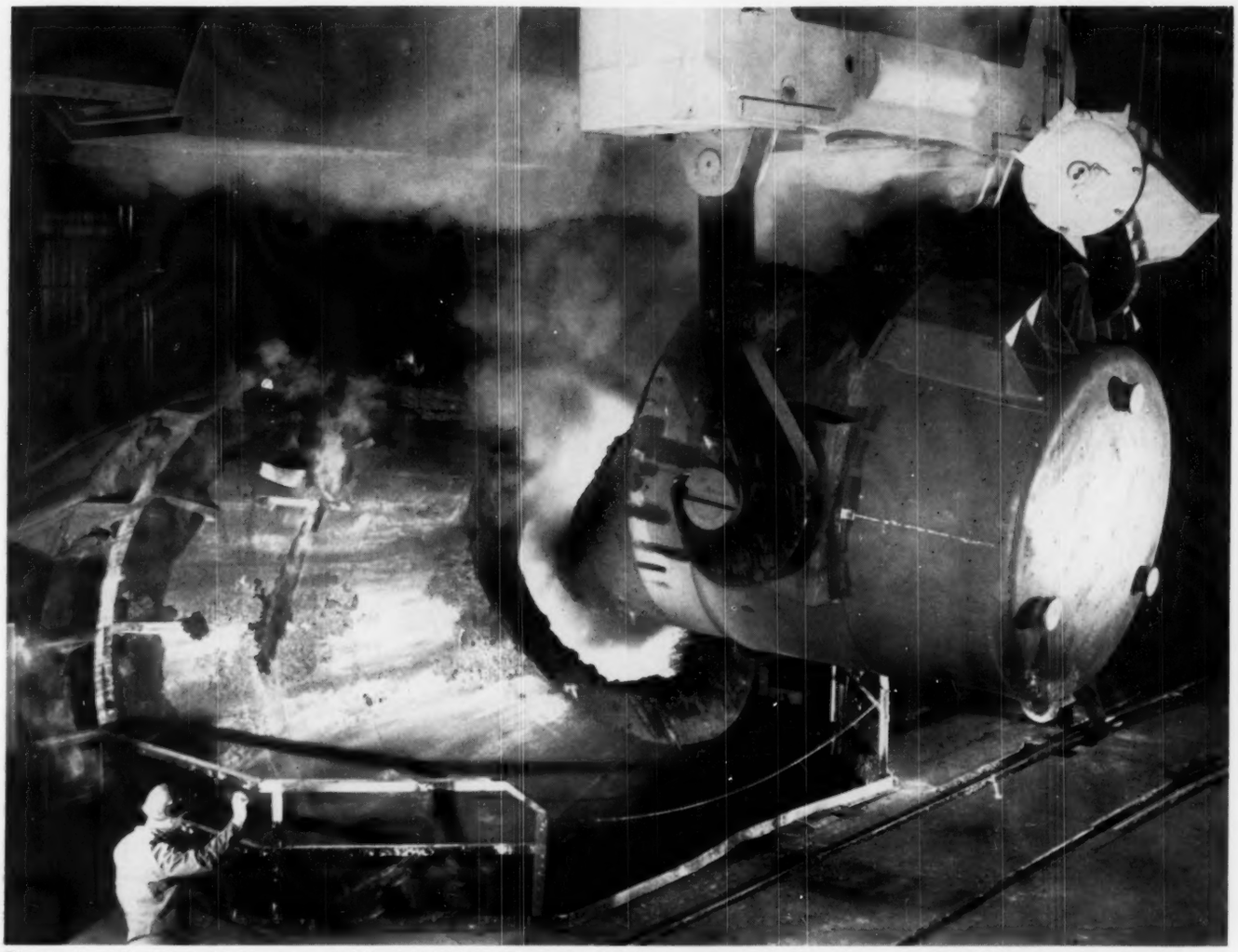


Figure 1 — Hot metal is transported from the blast furnaces to the new basic oxygen furnace at the Aliquippa works of Jones & Laughlin Steel Corp. and charged directly into the new facility. The charge for the new-type furnace is made up of scrap, hot metal and other materials.

J&L Starts Oxygen Steelmaking Process at Aliquippa Works

The new top-blown oxygen converter process promises to have far-reaching effects on future steelmaking technology . . . . steelmakers throughout the country will be watching the operation of the Aliquippa installation with great interest.

PRODUCTION of steel by the basic oxygen process began officially on Dec. 10 at the Aliquippa (Pa.) Works of Jones & Laughlin Steel Corp. It was the start of an operation that is expected to have a far-reaching effect on the industry.

Jones & Laughlin, the nation's fourth largest steel producer, is the first major steel company in the United States to use the basic oxygen steelmaking process. J&L's two furnaces—only one of which will operate at a time—have a total annual rated capacity of 750,000 tons. They are the largest in the world. The cost of the complete installation is about $11,000,000.

The decision to utilize the basic oxygen process was made by J&L after a thorough study of the economics and other factors involved in several other steelmaking processes. It was decided that the conditions at Aliquippa were best suited for the basic oxygen process. Aliquippa has five blast furnaces, giving it a good supply of hot metal, and enough mill scrap is produced to provide the quantities

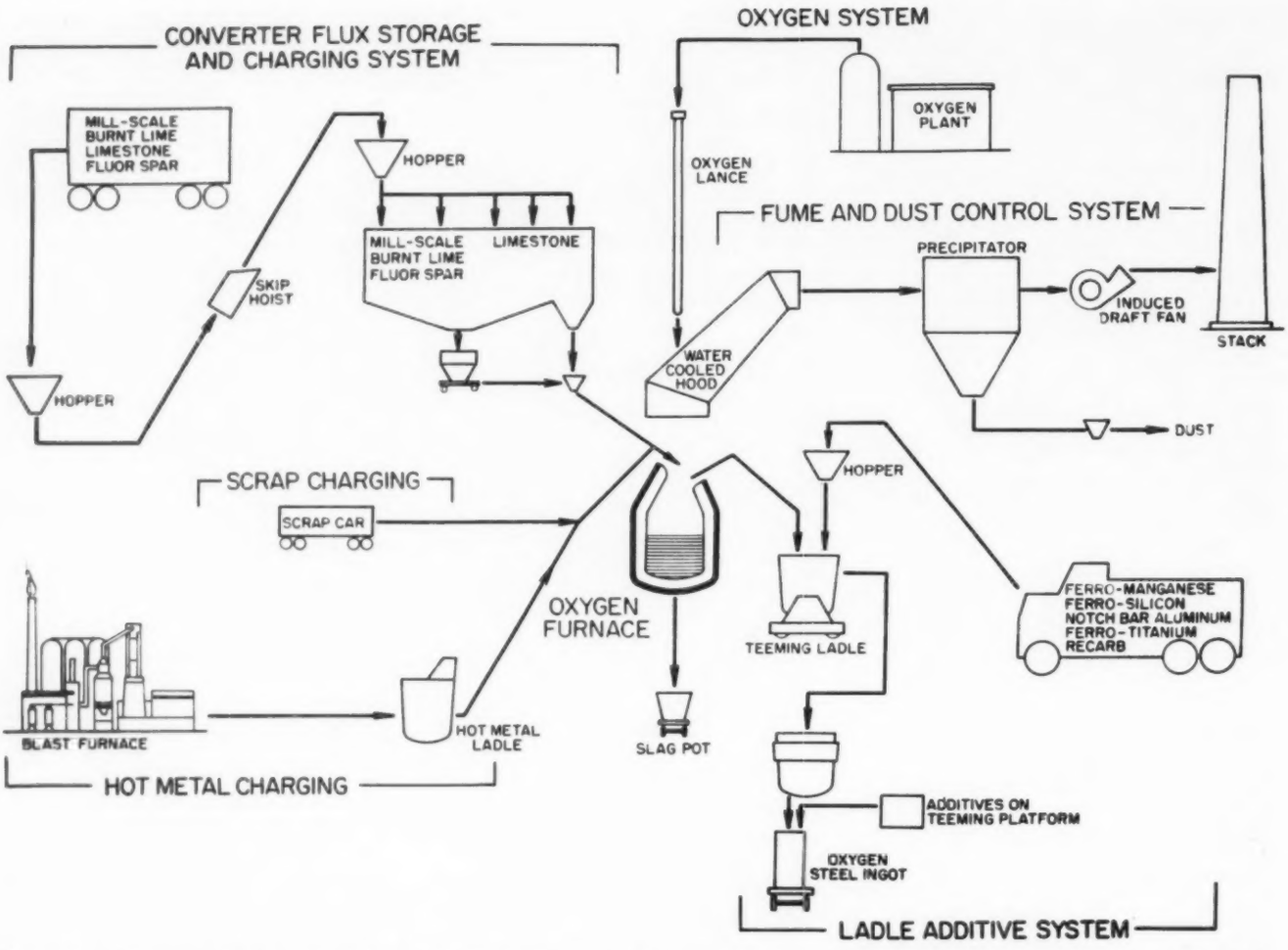


Figure 2 — Diagram shows material flow of new basic oxygen furnace processing installation at the Aliquippa works of the J&L Steel Corp.

used in the basic oxygen process. Although the basic oxygen process is essentially a European development, numerous refinements have been incorporated into the J&L installation by Kaiser and J&L engineers. The size, of course, is the biggest ever undertaken; many radical changes have been made in the layout of the plant, and the method used for cleaning gases is the first application to this process.

The basic oxygen furnaces eventually will mean a net increase at the Aliquippa Works of 400,000 annual ingot tons.

The two basic oxygen steelmaking furnaces at J&L's Aliquippa (Pa.) Works resemble bessemer converters although there are no tuyeres, wind box or blast pipe. Furthermore, since bottom linings are not unduly worn in the oxygen process, there is no need for a removable bottom as in the case of bessemer converters. The refractory lining of the furnace is about 38 in. thick and usually consists of a permanent lining of magnesite brick and an interior lining of pressed tar-dolomite brick with a layer of rammed mixture of tar-dolomite between the permanent and working linings.

The operation of the furnace is a relatively simple one. The charging is similar to regular converter practice and begins with the vessel being tilted to receive the scrap charge, amounting to 25 to 30 per cent of all metallics used. This is followed by hot metal and small quantities of roll scale and lime.

The furnace then is tipped upright and a water-cooled oxygen lance is lowered to a predetermined position above the surface of the bath. The oxygen is turned on (under pressure which is usually between 100 to 150 psi) and an instantaneous reaction occurs, leading to the formation of FeO, of which part goes into the slag and part enters the bath by diffusion. Carbon monoxide is evolved which starts a vigorous boiling action reaching to all parts of the charge. In the central reaction zone, temperatures are developed close to the boiling point of iron, which enhances the solubility of the oxygen and accelerates the diffusion of FeO throughout the bath, thereby resulting in a rapid oxidizing process. The carbon reaction speedily diminishes the FeO content of the slag.

The conclusion of the process is marked by a clearly visible drop in the flame at the furnace mouth. At this point the oxygen lance is withdrawn and the furnace is tilted to a horizontal position to permit the skimming off of fluid slag after which it is rotated to the opposite direction and the steel is poured into a conventional ladle.

The furnaces will produce at least 54 tons of steel per heat. As much as 81 tons have been made in one heat. A heat—from tap time to tap time—will take about 37 minutes. In a 24-hour operating day, production will approximate 40 heats. The life of the lining is

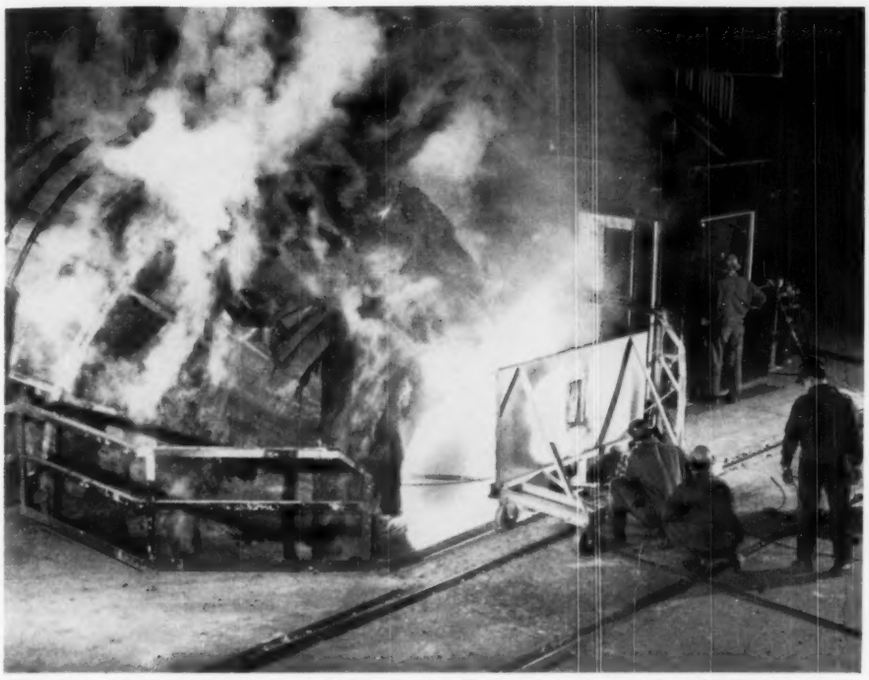


Figure 3 — Quality of each heat from the new basic oxygen furnace process is carefully controlled. Samples are taken before each heat is poured from the furnace.

estimated at between 300 to 400 heats.

Steel made by this process will be quite low in content of nitrogen, phosphorus and sulphur. Because of this, the steel produced by the basic oxygen process is characterized to a great extent by its high purity and ductility. At Aliquippa the steel from the oxygen furnaces will be applied to the production of welded pipe, tin plate, cold heading wire, welding rods and light structurals.

The basic oxygen process not only produces high-quality steel but the facilities can be constructed at a cost much lower than for traditional steelmaking methods. The basic oxygen furnaces at J&L represent a capital investment of only $15 per annual ingot ton as compared with at least $40 per annual ingot ton for new open hearth facilities, although a true comparison must consider the metallic supply, and will vary between plants.

J&L's basic oxygen steel plant was designed and built by Kaiser Engineers, Oakland, Calif.

One of the innovations on the J & L installation is a system for preventing air pollution from the new furnaces. Huge electrostatic precipitators have been installed which are designed to remove the suspended matter from the waste gases of the furnaces.

Water-cooled hoods have been built directly above the furnaces. The gases are drawn into them by fans capable of moving more than 200,000 cfm of gases. The gases are sprayed with water to remove the heavier material and to lower the temperature from 3000 to less than 500 F. The electrostatic precipitators, built by Research-Cottrell, then remove the fine dust.

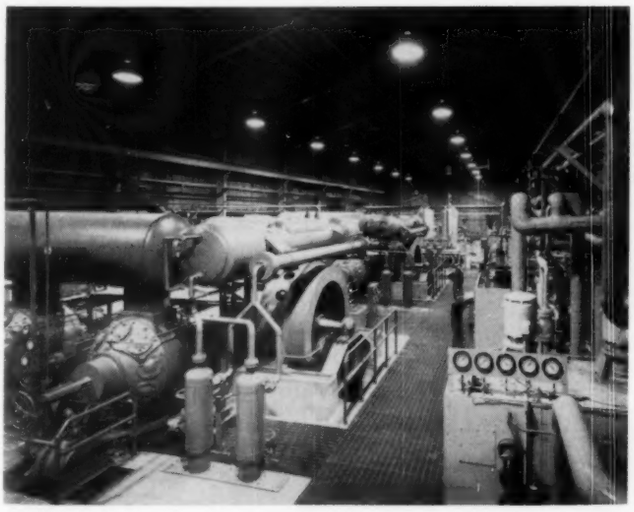
The principal auxiliary to the shop is an oxygen generating plant. Less than 2000 cu ft of oxygen are needed to produce a ton of steel in the basic oxygen process.

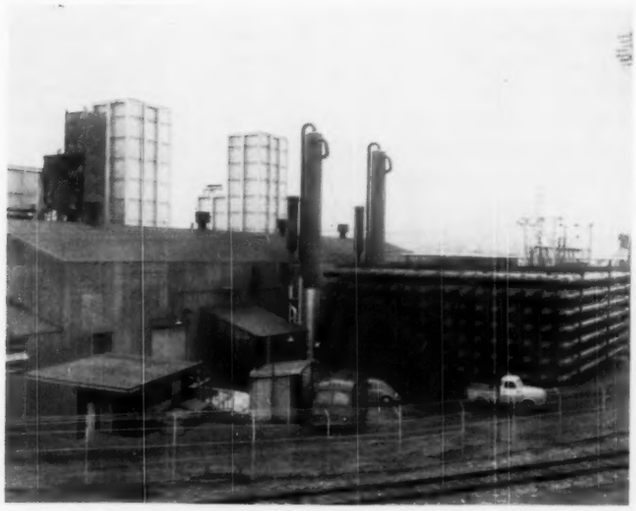
The new oxygen plants were designed, built and are operated by Air Products, Inc., of Allentown, Pa. Unusual features of the oxygen plants include a technical break-through in achieving low power consumption simultaneously with the extremely high reliability factor required by the steel industry.

Supplying oxygen to the new steelmaking process exactly as needed is no simple matter. High pressures, cyclic demand and the need for complete safety and reliability of supply combine to complicate the problem.

The new plants meet these problems by delivering a combination of

Figure 4 (left) — This is the compressor room of the oxygen facility serving the new basic oxygen furnace process. Air from these compressors is liquefied and distilled to make 99.5 per cent pure oxygen delivered under pressure, according to the demands of the process. Figure 5 (right) — Oxygen plant is rated at 230 tons per day. Liquid oxygen storage is provided for an equivalent of 6,000,000 cu ft of oxygen.





high pressure gas and liquid oxygen. Thus, several storage systems are used which permit complete flexibility of operation. Oxygen may be used over a wide range of flow rates and demand cycles. The liquid storage system permits either, or even both, plants to shut down without interrupting the flow of oxygen. All critical parts of each plant are installed as dual units for reliability. The risk of shutdown is remote. Many plants of similar design run for well over a year without a moment's shutdown. The identical plants eliminate possibility of oxygen failure.

Air Products engineers have effectively combined several previously distinct processes within each of the two plants.

The two new plants each produce 115 tons per day of oxygen at high purity (99.5 per cent), a high purity nitrogen stream (99.9 per cent), and the purest argon ever made commercially.

In addition to serving the needs of the basic oxygen process, the Aliquippa facility of Air Products also serves the oxygen needs of Jones & Laughlin for scarfing, open hearth and general plant requirements. A smaller facility, with a capacity of 100 tons per day of high purity oxygen, has served the Pittsburgh Works of Jones & Laughlin for about two years.

The new, multiple-unit oxygen-producing facility designed, built and operated by Air Products at Aliquippa for the basic oxygen process of the Jones & Laughlin Steel Corp., utilizes temperatures among the lowest ever commercialized in industry.

Because of their cold temperature, the oxygen plants are an imposing sight. All the complex maze of pipes, valves, refrigeration and distillation equipment is contained inside a giant structure called a "cold box." Air enters the cold box, warm and under pressure. Inside, it is refrigerated to about −300 F, and separated into oxygen, nitrogen and argon fractions in a distillation column, after which the products are rewarmed separately and withdrawn from the plant.

Each of the two big oxygen plants is substantially automatic in its operation and requires only occasional operator attention.

It is necessary, however, to shut down all low temperature plants for an annual defrost and routine maintenance check. Accordingly, both plants are designed so that they can produce a substantial fraction of their production as liquid oxygen. Liquid oxygen is stored on the site in a large, specially insulated storage system supplied with multiple pumping and vaporizing systems substantially identical to those in the oxygen plant. At any time, either or both of the oxygen plants may be shut down without interrupting the flow of oxygen. As the flow from either oxygen plant decreases below the demand level of the basic oxygen process, the oxygen pumping and vaporizing units of the liquid storage system go on stream, maintaining a constant flow of oxygen product. Liquid storage is equivalent to 6,000,000 cu ft of gaseous oxygen.

The basic oxygen process requires very large amounts of oxygen for short periods, several times each hour. In order to meet this cyclic need, a high pressure gaseous oxygen storage is provided which makes possible the accumulation of more than sufficient gaseous oxygen to "blow a heat" in the new furnace. This system places a large reserve of instantly available oxygen at any flow rate, high or low, and eliminates concern by the furnace operator for his supply of oxygen.

In plants of this type, which depend on very low temperatures for their operation, the costs of making and conserving refrigeration are a major fraction of the total cost of oxygen. Hence, a more efficient refrigeration cycle quickly pays its way in lower cost per ton of steel produced.

The new break-through involved in the Air Products Aliquippa plant is achieved by an ingenious combination of air compressors and two separate heat exchange systems.

Of the two heat exchange systems, the smaller uses shell-and-tube heat exchangers in which the products of air distillation, oxygen, argon and nitrogen, are passed through the exchanger counter-current to the flow of incoming air. By this means, the air is cooled almost to its liquefaction temperature by the products leaving the plant. This smaller heat exchange system requires a high pressure compressor in order to maintain a balance of refrigeration. The cost is low, however, because this portion of the total plant flow is small, about 30 per cent.

The larger of the two heat exchange systems employs rock filled regenerator vessels and operates in balance at a low input pressure substantially reducing the air compression requirements, hence reducing the power input for oxygen manufacture. The regenerators operate similarly to the "checkers" in an open hearth furnace, but at the opposite end of the temperature scale. In operation, low pressure air at about 85 psi pressure is passed through one of two large beds of extremely cold pebbles. The cold pebbles purify the air by freezing out water, carbon dioxide (which is always present in the atmosphere) and other possible contaminants. Before leaving the regenerator, the air is cooled almost to its liquefaction temperature, about 300 F below zero. While the incoming air is being refrigerated in one generator, the other regenerator vessel is flushed clean of carbon dioxide, water and other impurities and simultaneously cooled down to a very low temperature by outgoing cold nitrogen product. Thus, after a few minutes of operation, the flow is interrupted, the pressure equalized between the two vessels, the flow reversed and the cycle repeated.

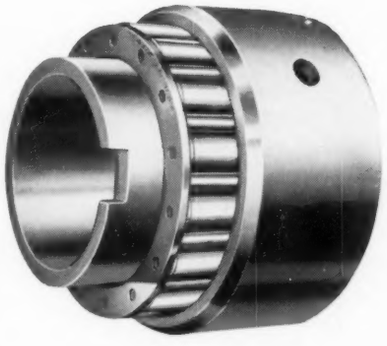
Reversing the flow in the big regenerator vessels is accomplished at the warm end by a system of automatically operated sequence valves. At the cold end of the regenerators, the flow is controlled by pressure actuated check valves.

In withdrawing oxygen product from the plant, the oxygen is pumped up to the required pressure while in the liquid state by a relatively small, efficient centrifugal pump. Then the oxygen is vaporized in the smaller heat exchanger, recovering its refrigeration and delivering the gas from the plant as a warm, bone dry, gaseous product at high pressure.

A real bonus from the operation of the tonnage oxygen plants is the production of two valuable by-products, pure nitrogen (99.9 per cent and higher) and ultra-high purity liquid argon, with impurities measured in only a few parts per million. ▲

How HYATT bearing advantages help produce more steel at lower cost:

ON INGOT CARS—HYATTS TAKE THE SHOCK LOADS OF A STRIPPER 'ROUND-THE-CLOCK!



The shock loads of a stripper pounding a 10-ton ingot free from a mold has little effect on rugged HYATT bearings. In ingot cars like the ones above, HYATT'S straight cylindrical design provides maximum load-carrying capacity with ample reserve for overloads and radical temperature changes. HYATT Hy-Rolls greatly reduce friction and starting power requirements—permit longer trains, faster and smoother car-spotting. For years now, HYATT service-proved advantages have made them the first choice of the steel industry—and constantly-improved quality makes HYATT more than ever your best buy today! It *pays* to standardize on HYATTS! Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.; Pittsburgh; Detroit; Chicago; Oakland, California.

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HYATT HY-ROLL BEARINGS FOR STEEL INDUSTRY

Republic's Expansion Program Nears Completion

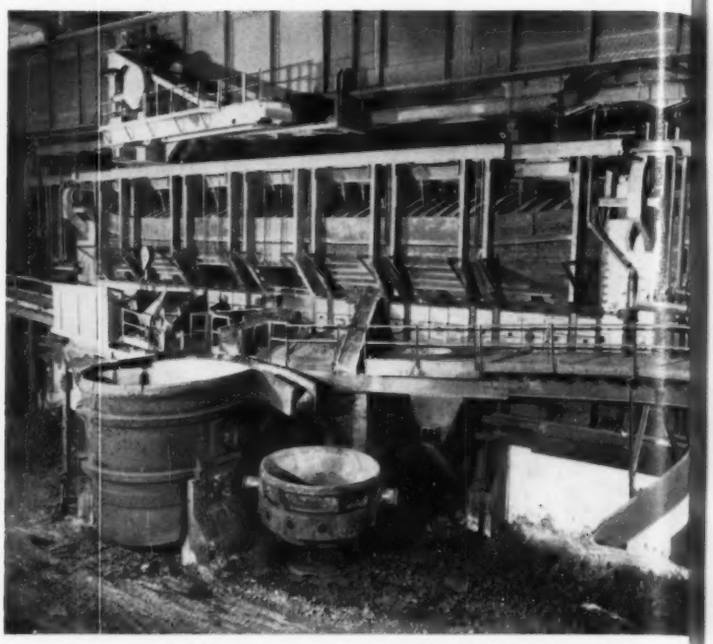


Figure 1 — Republic's expansion at Cleveland gives the plant six of these 7-door open hearth furnaces which turn out 400-ton heats.

REPUBLIC Steel Corp. is nearing completion at its Cleveland plant of the biggest single steel expansion in Ohio history.

The program will increase the annual ingot capacity of the Cleveland plant by 788,000 tons to 3,360,000 tons. It follows by just five years another steel expansion which had added 672,000 to productive facilities of Republic in Cleveland.

This is part of an over-all program which will boost Republic's total

Figure 2 — Sixteen new one-way-fired soaking pits heat ingots for the new universal slabbing mill.

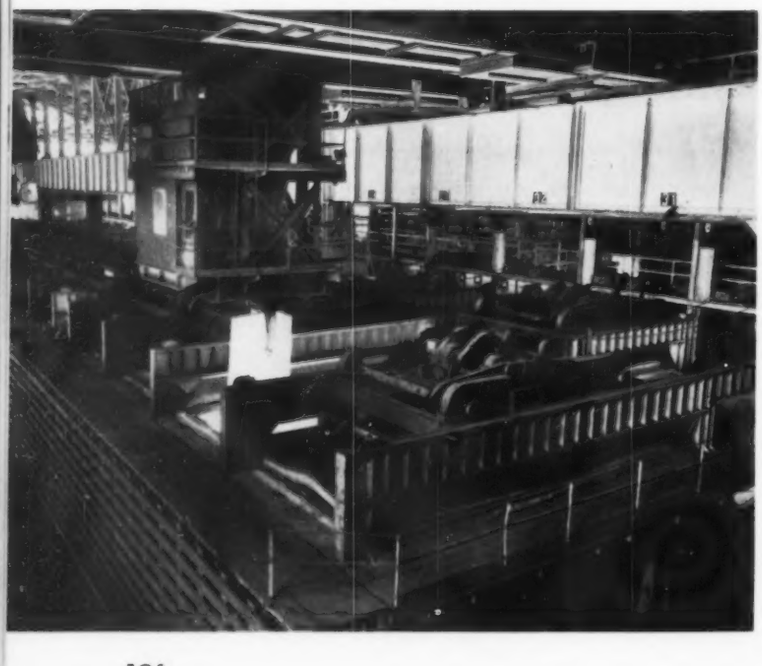
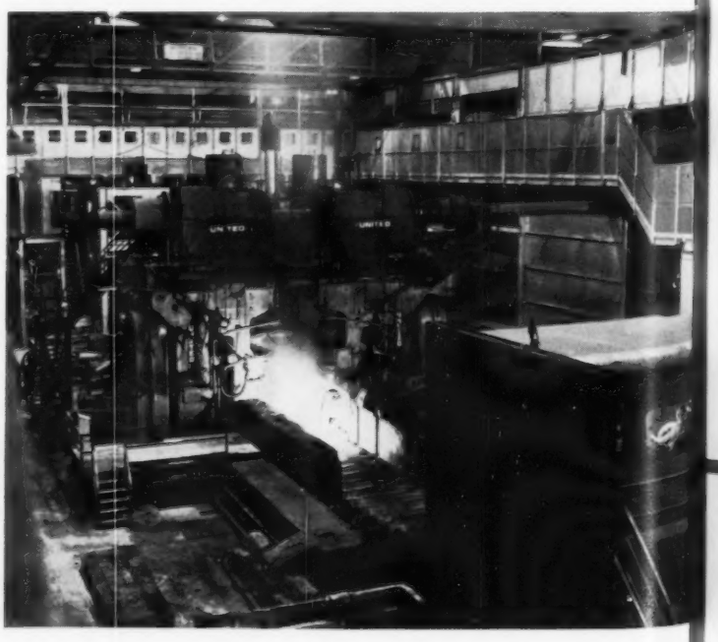


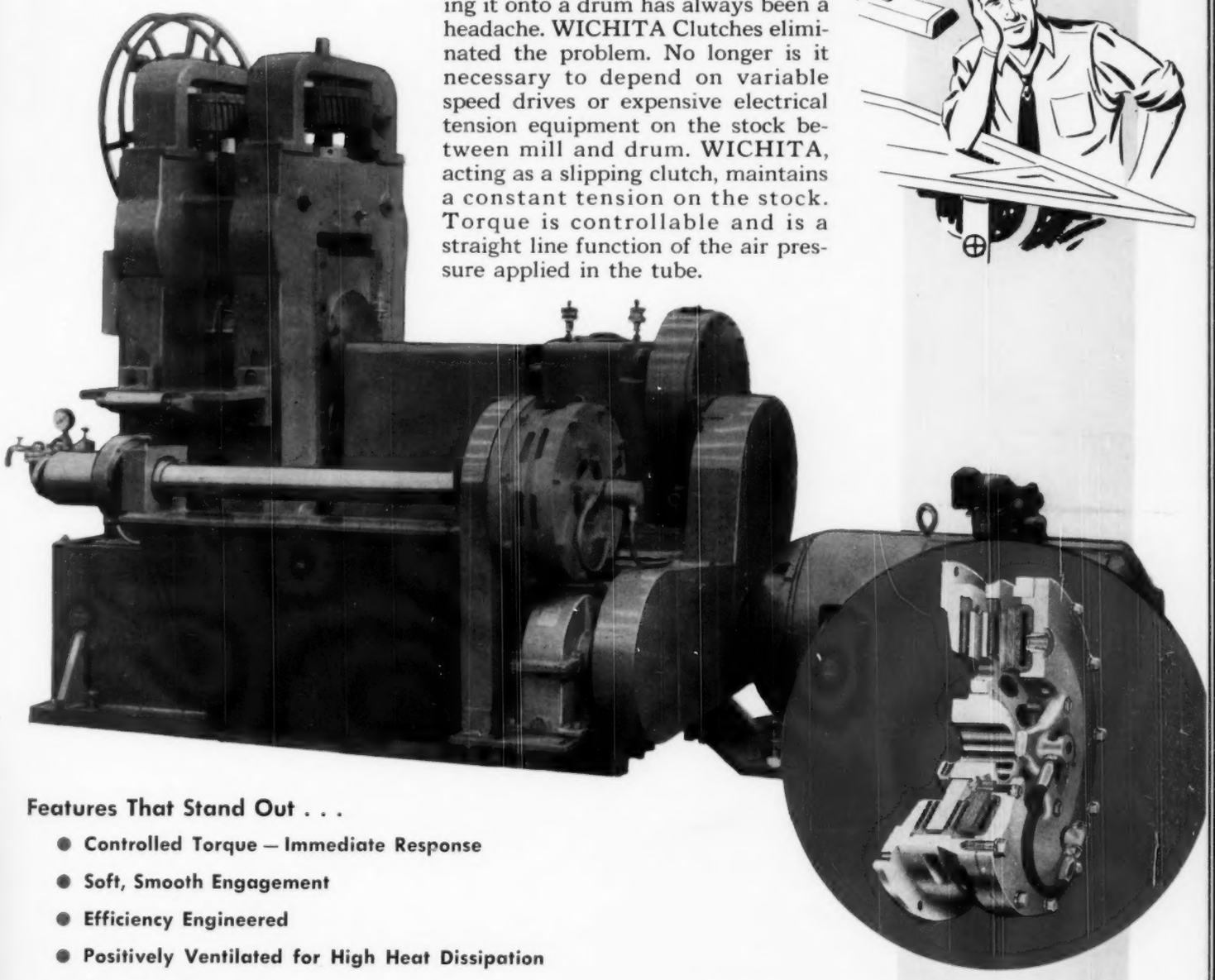
Figure 3 — This 45-in. universal slabbing mill reduces ingots up to 25 tons in weight into slabs up to 75 in. wide.



Fenn Manufacturing Company of Newington, Conn., Writes:

"WICHITA WAS THE REMEDY FOR OUR HEADACHE !"

Rolling thin-gage material and coiling it onto a drum has always been a headache. WICHITA Clutches eliminated the problem. No longer is it necessary to depend on variable speed drives or expensive electrical tension equipment on the stock between mill and drum. WICHITA, acting as a slipping clutch, maintains a constant tension on the stock. Torque is controllable and is a straight line function of the air pressure applied in the tube.



Features That Stand Out . . .

- **Controlled Torque — Immediate Response**
- **Soft, Smooth Engagement**
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- **Extremely Long Life**
- **Easier Maintenance**

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Robert R. King Co., Cleveland, Ohio

Allied Transmission Equipment Co.
Kansas City 8, Missouri
Norman Williams, Houston, Texas
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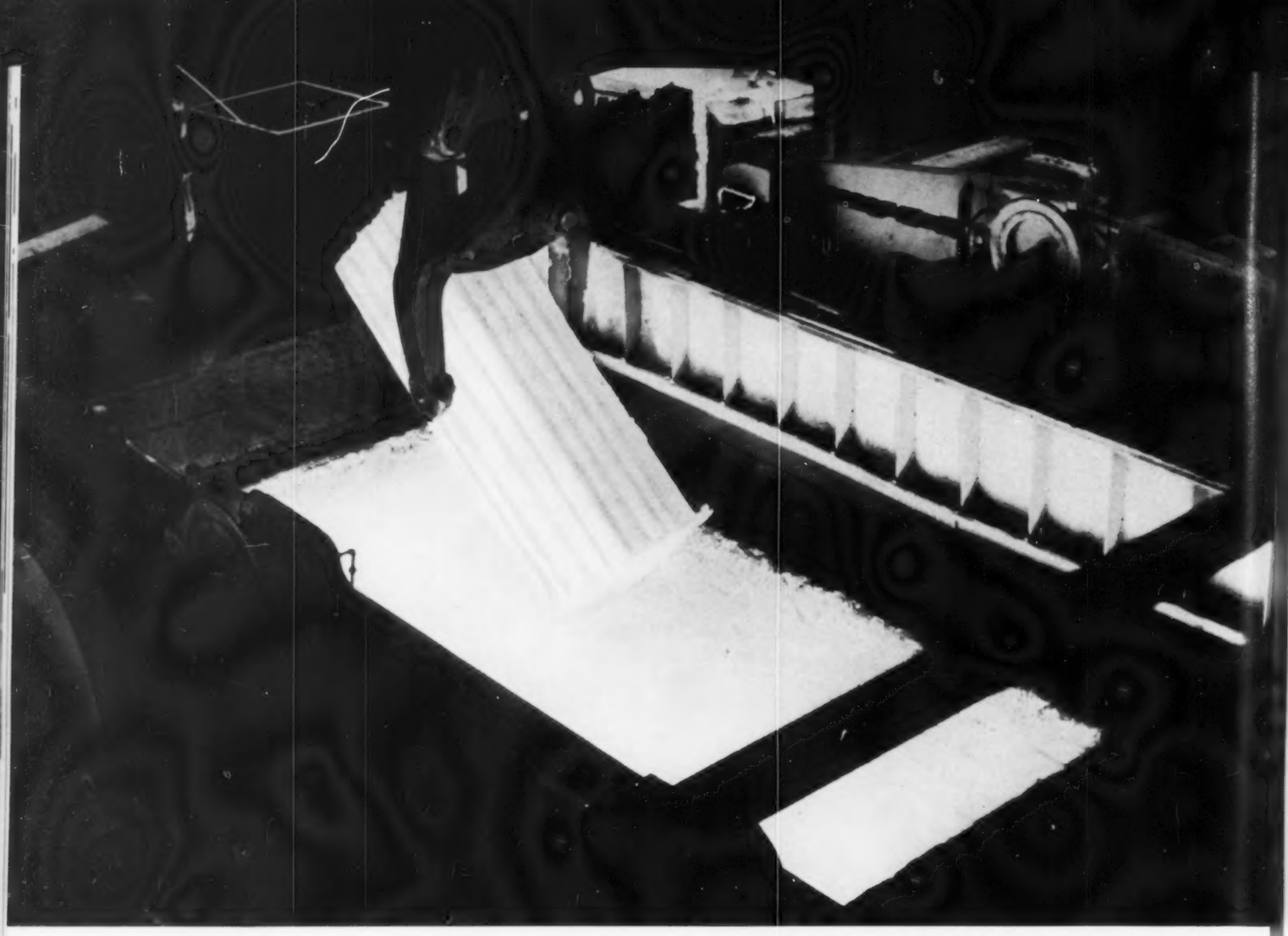
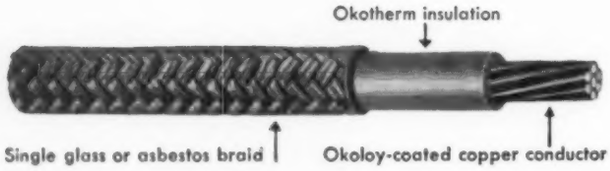


The soaking pit—a typical power and control circuit application for Okotherm-insulated wires and cables.

OKOTHERM . . . a service-proved electrical insulation for high ambient temperatures



Used on overhead cranes in open hearth rooms and around soaking pits, as power feeders, motor, control, and lighting circuits, wherever high temperatures are routine, Okotherm-insulated cables have set amazing records for service life.

Why? They offer all the characteristics essential for dependable circuit operations in these high temperature locations. Extraordinary heat resistance . . . high temperature compressive strength . . . all-temperature flexibility . . . resistance to ozone . . . high dielectric strength—all these mean greater reliability, longer service in locations too hot for other cable constructions.

Okotherm is a thermosetting insulation compounded of silicone rubber. It is an almost entirely inorganic, Class H insulation that may be used for continuous operation at 150C (as high as 200C under certain conditions).

Okotherm-insulated wires and cables are available with a protective covering of glass, asbestos, orlon or nylon braid; and if required, a seamless aluminum sheath overall. For complete details contact your local Okonite Representative . . . or write for Bulletins IS-2117 and IS-1088. The Okonite Company, Passaic, New Jersey.

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where there's electrical power . . . there's **OKONITE CABLE**

capacity to 12,242,000 ingot tons annually, an increase of 19 per cent from the 10,262,000 capacity the company had two years ago. In the same period, the industry as a whole has increased capacity by nine per cent.

Six weeks ago, the completion of the Republic expansion at Gadsden, Ala., was announced. By next spring, the entire program of the company will be finished.

In the Cleveland expansion, Republic:

1. Added two new 375-ton open hearth steelmaking furnaces, and enlarged four other open hearths from a rated capacity of 275 tons to 375 tons per heat.
2. Added a new 45-in. universal slabbing mill which can roll steel ingots weighing up to 25 tons into slabs ranging up to 75 in. wide.
3. Added 16 new soaking pits to heat ingots for the slabbing mill.
4. Expanded the approaches to the 98-in. hot strip mill to permit straightaway rolling of steel slabs up to 75 in. without broadside rolling.
5. Added one new coke oven battery to replace an old one and has work in progress on replacement of other old batteries in the No. 1 coke plant.

The expansion has made Republic's Cleveland plant the state's largest.

Even with open hearth heats running up to 400 tons, the Cleveland plant, with some of the largest ladles in the world, taps the entire heat into one ladle.

Space for the new slabbing mill and its buildings had to be carved out of an area already completely built up with service shops which had to be torn out and relocated before work could begin.

New buildings to house these shops were constructed on Independence Road. They include new mechanical and electrical shops and a new storeroom with 145,000 sq ft of floor space.

Limited by a 12-in. bar mill on one side and a 44-in. blooming mill on the other, the new slabbing mill required special engineering and design to fit it into the available space.

At the south end of the mill building, 16 new soaking pits with a heating capacity of 120,000 tons per month were constructed.

Slabs leaving the mill pass through an automatic scarfing machine and on to the slab shear. After cropping, the slab moves to an automatic marking machine which will stamp up to 18 characters on its end. The marker will indicate the weight, ingot number, heat number and cut designation.

To handle the wider slabs, Republic's 98-in. hot strip mill was modified last summer. The change raised its monthly capacity from 160,000 to 203,000 tons per year. The building housing the strip mill was extended by 144 ft at one end. The finishing mill building was extended by 360 ft at the other end.

The strip mill now is able to handle slabs up to 24,000 lb compared with a maximum of 18,000 lb previously. Heating capacity was enlarged by the addition of a fifth 100-ton-per-hr slab heating furnace.

Construction work on the new coke oven batteries is continuing. One new battery of 51 ovens was placed in operation last summer. By next summer a second new battery of 51 ovens will be ready for operation and several weeks later, work should be completed on a third battery. ▲

In FRICTION SAWING it's ENTERPRISE that counts

ENTERPRISE Crop-End Saw, for ½ to 4½ in. OD pipe or tubing. Turret drive end.

For high speed cutting of hot or cold steel sections, production men agree that *friction sawing* has no equal.

ENTERPRISE Mill-Type Friction Saws are available for multiple or crop end cutting of steel pipe, tubing, solid bars, channels, and other steel sections.

ENTERPRISE provides synchronized handling tables and conveyor systems for completely automatic operation.

Write for ENTERPRISE Bulletin #502

ESTABLISHED 1878

THE ENTERPRISE COMPANY

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U. S. Steel Engineer Develops Technique for Rolling of Wide, Thin Sheets

THE answer to an aircraft industry prayer may be found in a research and development project being undertaken by United States Steel Corp. The ultimate solution is the possible production of thin stainless and alloy steel sheets rolled to widths never before achieved.

This has been accomplished by a "sandwich" rolling process developed by Howard S. Orr. Through this process, U. S. Steel has demonstrated the feasibility of producing steel sheets up to 90 in. wide—nearly twice the width of light-gage stainless and alloy sheets now being made by conventional methods.

These and the even wider stainless and alloy sheets that may become available as a result of this pioneering effort by U. S. Steel can reduce the over-all weight of the aircraft and missiles by eliminating many of the joints and seams now necessary in the fabrication of airframe parts and "skins" from narrower sheets.

At the same time, the advantages of stainless and alloy steels—strength, toughness and resistance to heat and corrosion—will be retained.

The new method consists of sandwiching stainless or alloy steel plates between two heavier plates of ordinary carbon steel, closing the assembly with welded-in side and end bars, and—after heating—rolling the "sandwich."

A typical experimental "sandwich" rolled at U. S. Steel's Homestead District Works contained four 12 per cent chromium stainless plates, each $\frac{5}{16}$ in. thick.

These were enclosed in carbon steel cover plates each 1-in. thick so that the assembly, after welding, was about 3 in. thick. The "sandwich" was heated by conventional practices and rolled down to a plate $\frac{3}{8}$ in. thick, 100 in. wide and 250 in. long.

This amounted to a total reduction of about 90 per cent with this reduction being effected in each individual component in the assembly. As a result, the original stainless plates that were $\frac{5}{16}$ in. thick were rolled to a nominal thickness of 0.033 in. each. When the expendable end and side bars were sheared off to open the assembly, the stainless sheets measured 90 in. wide and 230 in. long.

Contributing to the significance of the results achieved to date is the fact that existing rolling mills have been used. In rolling, the "sandwiches" have the working characteristics of the carbon steel cover plates rather than the stainless or alloy steels inside so that no revamping of rolling mills to supply more power or stiffen the rolls has been necessary.

Having demonstrated that Mr. Orr's process could be utilized to explore new ground in the search for improved materials for aircraft and missiles, U. S. Steel is now focusing its attention on refining the "sandwich" rolling technique.

Studies are being conducted to determine the best "sandwich" design and assembly methods, as well as to develop suitable ways to heat treat, quench, flatten and finish the sheets to meet the exacting requirements of the aircraft and missile industry. Engineering studies must be made to determine the additional equipment to put the process in production.

Many other potentials are seen for the "sandwich" process, among which are the production of "difficult to roll" steels that have high strength at elevated temperatures or become brittle at normal rolling temperatures in wide widths on existing mills. ▲

Figure 1 — The plates inside the sandwich have been "buttered" with a special separating compound to avoid sticking when the assembly is hot rolled. The sandwich rolling technique has yielded the widest sheets ever produced on existing mills. One rolling produced sheets 90 in. wide and 230 in. long—as much as twice the width of sheets produced by conventional methods heretofore.

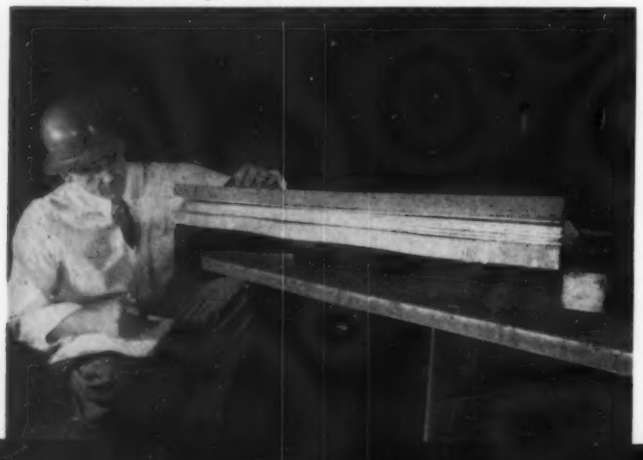
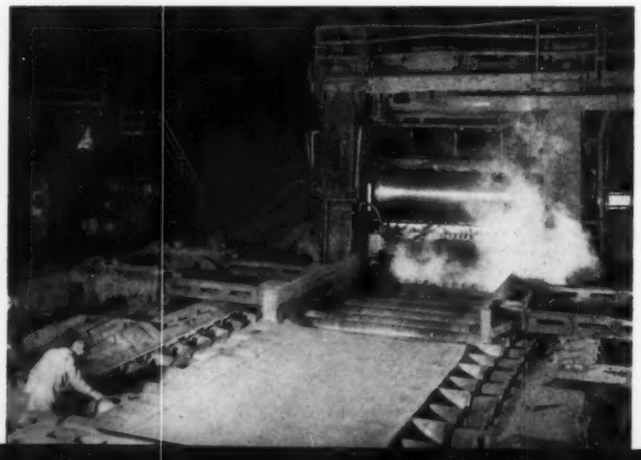


Figure 2 — After cooling, the ends and sides of the flattened "sandwich" are cut away and the carbon steel cover plates removed to reveal the thin, wide stainless sheets inside. The process can be used with stainless and alloy steels, most of which are difficult to roll under ordinary conditions.



Why should you pay

for top quality in "Commercial Grade" Roller Bearings . . . AND NOT GET IT?

It's *wasteful* to pay for quality you don't need. It's *negligent* to pay for quality you don't get.

From the simplest steel-cage type to the finest segmented-retainer type, Rollway "commercial grade" Tru-Rol Roller Bearings incorporate as closely as possible design and construction principles found normally in a Rollway maximum-type precision bearing.

Take the segmented-type Tru-Rol for example. Each deep-section separator segment is formed to fit the curvature of the roller. Each roller has a separator segment to keep it in accurate alignment. And each roller is crowned to distribute load evenly along the full length of the roller.

That's a lot different from small-diameter, unground spacers staggered at unequal intervals, resulting in rollers rubbing in opposed-motion, and non-uniform roller distribution that can set up out-of-balance vibration and "pulse".

Let a near-by Rollway Service Engineer consult with you on your bearing problems No charge. No obligation. Just write us. Rollway Bearing Co., Inc., Syracuse, N. Y., *manufacturers of a complete line of radial and thrust cylindrical roller bearings.*

Cutaway view of Rollway Tru-Rol® segmented-retainer roller bearing . . one of three distinct types of Tru-Rol bearings available.

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Retainer Operation

☐ Is the retainer roller-supported, to reduce sliding friction?

Retainer Construction

☐ Is the retainer strong enough to withstand shock loads and sudden reversals?

(A Rollway segmented-type steel retainer, such as that illustrated, is the strongest, most durable available in commercial grade bearings.)

Roller Spacing

☐ Are all rollers equally separated, or do some rub against each other in opposed-motion friction?

☐ Are rollers distributed evenly to prevent "pulse" and vibration?

Roller Construction

☐ Are the rollers crowned for optimum load distribution?

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Products for steel: motors, m-g sets, rectifiers, control, pumps, *Texrope* drive equipment, crushers, grinding mills, screens, transformers, unit substations, switchgear, circuit breakers, turbine-generators, voltage regulators, blowers, compressors, condensers, and water conditioning equipment.

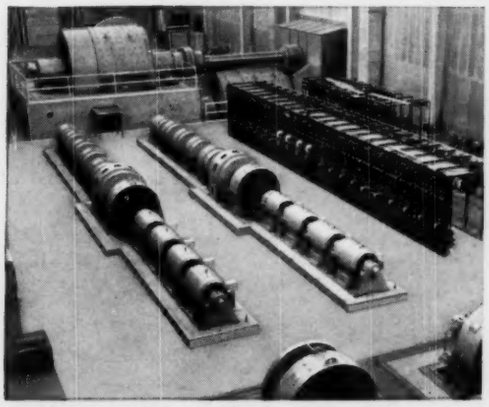
ALLIS-

s. in Step with STEEL

The blooming mill

Maximum electrical efficiency is assured in blooming mill operations where Allis-Chalmers equipment is used. From switchgear to drive motors, Allis-Chalmers offers a tailored system — engineered by mill experts and designed to keep high quality blooms rolling fast and accurately.

From mine to final processing—Allis-Chalmers equipment is in step with the increasing tempo of expanding steel production. Contact the nearest A-C office in your district, or write Allis-Chalmers, Milwaukee 1, Wisconsin.



Blooming mill motor room view shows components of the Allis-Chalmers electrical package. Switchgear, control, constant and variable voltage motor-generator sets, *Regulex* motor-generator sets, liquid rheostat, and twin drive motors are designed to work together for peak mill output.

Regulex and *Texrope* are Allis-Chalmers trademarks.

s- CHALMERS

A-C ALLIS-CHALMERS

A-5411

"No secondary cleaner required with a P-A Washer"

...says FURNACE SUPERINTENDENT

This economical feature of the Pease-Anthony washer is only one of the many reasons why P-A is first choice with blast furnacemen.

It's a "natural" where high top pressures are used . . . puts full top pressure to work cleaning gas . . . low water consumption . . . low initial cost with minimum maintenance requirements . . . compact design requires little space.

Units available for capacities ranging up to 150,000 SCFM. Write for descriptive bulletin.

Performance summary of some P-A Washers now in use:

Installation	Years Operated	Volume SCFM	Pressure Drop Inches Water	Dust Loading Grains/SCF	
				Inlet	Outlet
A	4	78,000	30	3-19.0	.01-.04
B	3½	78,000	30	2-3	.02-.08
C	3	85,000	30-40	2-3	.01-.03
D	3	45,000	30	2	.02-.03
E	½	75,000	50	—	.02
F*	½	26,000	12	5	.10
G*	½	26,000	12	5	.10
H	½	90,000	29	—	.04

Installation C is in Illinois. Installation H is in Texas. All others are in Pennsylvania.

*Two units in parallel on one furnace. Lower efficiency due to lower available top pressure.

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P-A GAS SCRUBBERS

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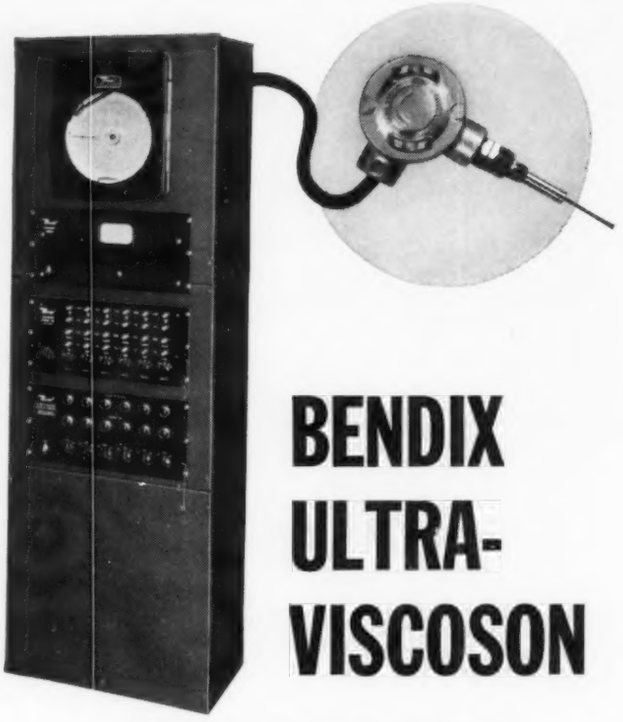
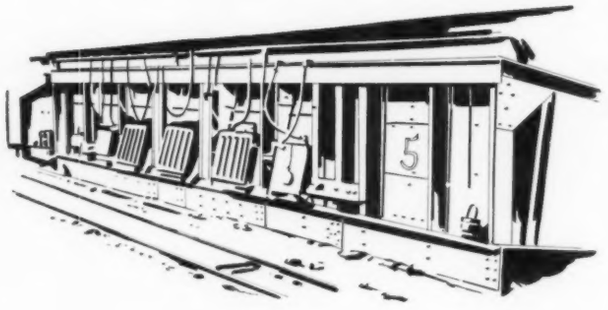


BENDIX ULTRA-VISCOSON

Automatically controls fuel viscosity for highest combustion efficiency



Bendix Ultra-Viscoson* can save you money by reducing heating time, furnace maintenance and fuel costs. Viscosity is a big problem in obtaining proper atomization of fuels and uniform flame characteristics for open-hearth furnaces, steam generating power plants, and glass-melt furnaces. BLOWOUTS, SPUTTERING, and POOR COMBUSTION can all result from too low or too high a viscosity.

Bendix Ultra-Viscoson eliminates these problems by automatically controlling the flow of heat exchange fluid to the pre-heater. Precise control of viscosity is maintained by continuously adjusting temperatures.

For complete information, contact the Cincinnati Division, Dept. 380, 3130 Wasson Road, Cincinnati 8, Ohio. *REG. U.S. PAT. OFF.

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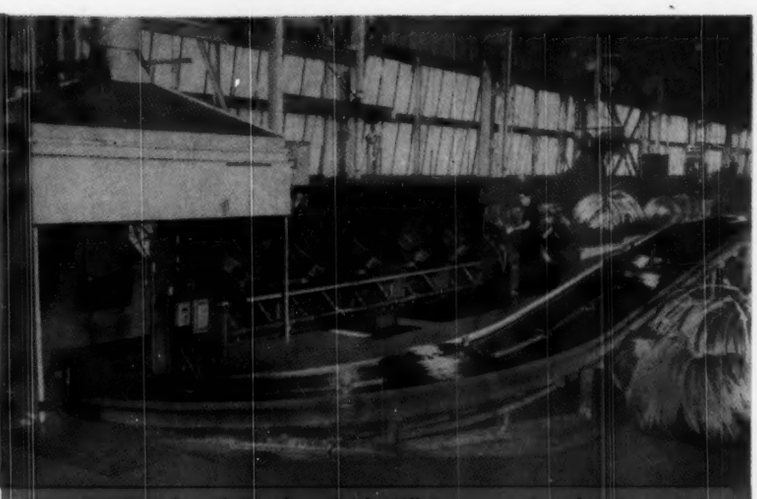
Cincinnati Division

Bendix AVIATION CORPORATION

Waterbury Farrel TANDEM ROD MILLS *in Action . .*



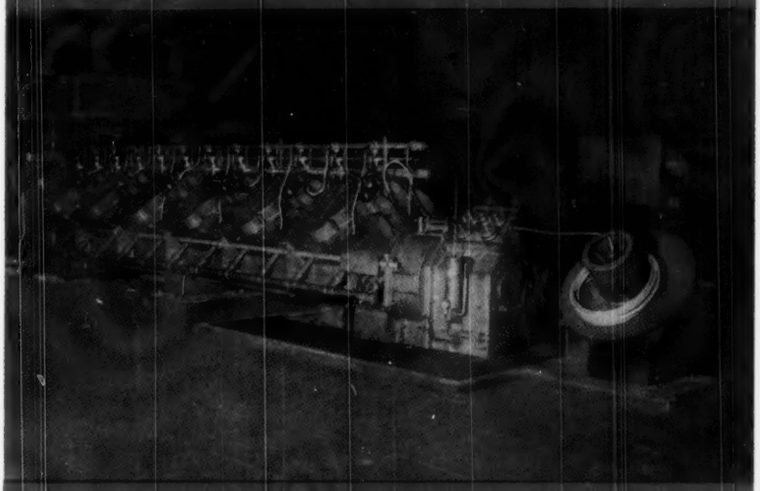
7" x 2" Ten Stand Tandem Rod Mill in operation for Anaconda American Brass Ltd. (Subsidiary of the American Brass Co.) New Toronto, Ontario, Canada. Starting size 25/32" round rod and finishing to .314" modified square at 250 feet per minute.

You can reduce 1" rod down to 5/16" efficiently and economically on Waterbury Farrel Tandem Rod Mills. Here are the specific advantages provided by these mills over the older process of drawing through dies after the 3-high mill operation:

Advantages

ROLLED ROD

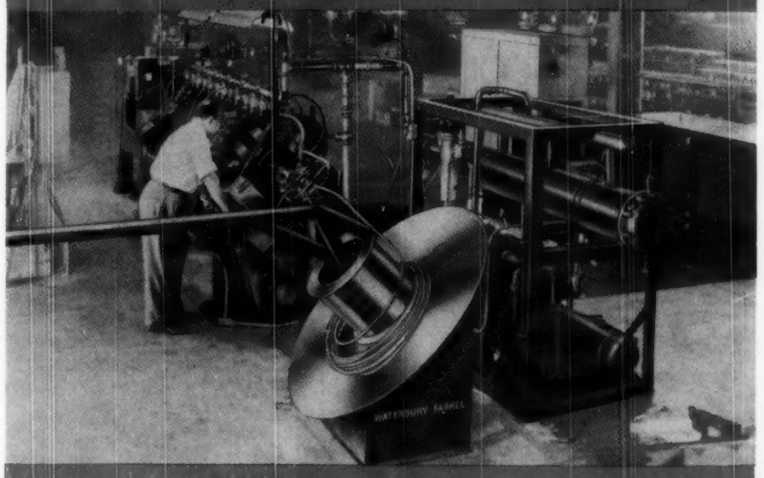
- Does not Require Pointing.
- Much greater reduction in single pass.
- Greater Production rate.
- Reduces handling time.
- Anneals at lower temperature and results in better surface and grain structure.
- Eliminates intermediate annealing or pickling.



7" x 12" Twelve Stand Tandem Rod Mill installed in Bristol Brass Corp., Bristol, Conn. Starting size ¾" round rod and finishing to .250" modified square at 400 feet per minute.

Represented at the right are a few of the companies taking advantage of these production benefits. Each installation illustrates Waterbury Farrel's custom-engineering ability to design and build rugged, dependable equipment for specific production needs. Whatever your rod requirements may be, Waterbury Farrel can furnish a Tandem Rod Mill to fit your program.

Write today, for your free copy of Tandem Rod Mills Circular No. 729-R.



7" x 2" Ten Stand Tandem Rod Mill in operation at H. M. Harper Co., Morton Grove, Illinois. Starting size 9/16" round rod and finishing to .188" modified square in speed ranges from 85 to 253 feet per minute.

THE WATERBURY FARREL FOUNDRY & MACHINE CO.

WATERBURY, CONN., U.S.A.

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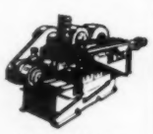
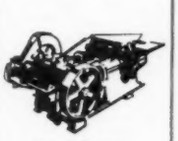


Bolt, Nut & Screw Machinery

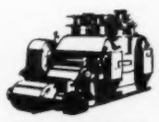


Power Presses

Rolling Mill Machinery

WATERBURY FARREL FOUNDED 1831

Wire Mill Equipment



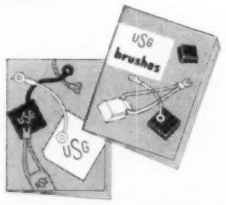
Sendzimir Mills and Other Special Machinery

THIS USG® BRUSH REDUCES MAINTENANCE ON ALL MILL MOTORS

The brushes in steel mill motors and generators don't cost much, but they can make or break a production schedule. Run up maintenance costs, too. The economical USG Brush Grade 223 can reduce maintenance on motors because of its long-wearing qualities. The proven success of USG Brush Grade 223 is a result of fifty years' experience on all types of mill motors under all conceivable conditions.

But not only does the USG Brush 223 have a longer life . . . it has a permanent shunt connection found on all USG Brushes . . . called STATITE®. The shunt can't be jerked out and will not jar loose.

For low mill motor maintenance and longer brush life with minimum wear, specify the USG Brush Grade 223 with the permanent shunt connection, STATITE.



Copies of the latest USG Brush Catalog B-56 and the new USG Brush Grade Supplement are available on request.

B-254-1

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 9, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

Date-line Diary...

December 2

Δ Lead sold in London at 9.93¢ per lb, New York price is 13½¢; this spread will permit shipments from London to U. S. consumers at about 12¢ a lb.

Δ The AISI reports that the operating rate of the steel industry for the week of December 2 is scheduled at 72.0 per cent of capacity. This is equivalent to 1,843,000 tons compared with 1,846,000 tons one week ago and 2,493,000 tons one year ago. Index of production for the week is 114.7.

December 3

Δ Florida Steel Corp. offers 80,000 additional common shares to stockholders at $10.50 per share, at the rate of one share for each ten shares held, with the privilege of additional subscription. Proceeds will be used to partly finance the construction of an electric steel furnace and rolling mill near Tampa with a capacity of 25,000 to 30,000 tons a year.

Δ Price of lead in New York was reduced ½¢ to 13¢ a lb.

Δ The Federal Reserve Board reported that consumers increased their installment debt by $85,000,000 in October to $43,000,000,000.

Δ The Bureau of Mines reported that the consumption of scrap during October, 1957 totaled 5,338,000 gross tons, pig iron used was 5,670,000 gross tons compared with 5,033,998 tons of scrap and 5,645,036 tons of pig iron in September, 1957.

Δ Shipments of iron and steel castings during September, 1957 amounted to 1,191,598 short tons compared with 1,287,309 short tons in August, 1957 and 1,334,369 short tons in September, 1956.

December 4

Δ The American Steel & Wire Div., U. S. Steel Corp. shut down its smaller furnace at Cleveland, also a 45-coke oven battery.

December 5

Δ Government figures showed that construction outlays for November, 1957 amounted to $4,100,000,000, down $400,000,000 from October, 1957 but 4 per cent above November, 1956.

Δ R. S. Reynolds, Jr., president of Reynolds Metals Co., predicted before the Investment Bankers Assn., that aluminum use will rise to 10,000,000 tons by 1975 (currently it is 2,000,000 tons).

Δ The Bureau of Mines, U. S. Dept. of the Interior, reported that marketed production of natural gas in the U. S. in 1956 totaled 10,082,000,000,000 ft, an increase of 7 per cent, consumption was 9,707,000,000,000 cu ft.

December 6

Δ Freight loadings on U. S. railroads dropped to 553,722 cars last week (which included the Thanksgiving holiday), 26.4 per cent under the comparable 1956 week (week after Thanksgiving). For the four weeks ended November 30, total loadings were 14.6 per cent below the same 1956 period.

Δ The Bureau of Mines reports that estimated production of Pennsylvania anthracite for November, 1957 equals 1,938,000 net tons, compared with 2,274,000 tons in October, 1957 and 2,629,000 in November, 1956.

December 9

Δ Tin prices soared in world market; in London tin for three-month delivery, reached 91¾¢ per lb, a 6¾¢ rise. Quotations were buoyed by International Tin Council's decision to slash export quotas of the six tin production countries 28½ per cent below the rate of shipments for the year ended September 30.

Δ The AISI reports estimated payroll for the iron and steel industry for October, 1957 amounted to $345,580,000 compared with $330,076,000 in September, 1957. Estimated total employment was 640,300 compared with 650,800 during September. Average hourly payroll cost per wage earner was $2.992, compared with September cost of $3.022. Average hours worked a week was 38.0 compared with 36.4 in September. The estimated payroll for the first ten months of 1957 is $3,387,430,000.

Δ The AISI reports that the operating rate of the steel industry for the week of December 9 is scheduled at 69.4 per cent of capacity. This is equivalent to 1,777,000 tons compared with 1,831,000 one week ago and 2,522,000 tons one year ago. Index of production for the week is 110.6.

December 10

Δ The AISI reports that the shipments of finished steel products for October, 1957 totaled 6,550,690 net tons compared with 6,171,674 tons in September, 1957 and 7,930,957 tons in October, 1956. Shipments of finished steel products for the first ten months of 1957 totaled 69,155,531 net tons, 400,000 tons greater than shipments for the same period in 1956.

December 11

Δ The American Iron Ore Assn. reported that the Great Lakes Iron Ore shipping season ended with a total of 84,614,734 gross tons, compared with 77,633,027 tons transported in 1956.

December 12

Δ The Labor and Commerce Depts. reported that unemployment rose in mid-November to 3,200,000, 700,000 over the mid-October figure; employment fell to a total of 64,900,000 off 1,100,000. Factory jobs decreased 230,000 during the month, reflecting cutbacks in the metals, machinery and aircraft industries.

December 13

Δ The Commerce Dept. and SEC reported that business outlays for new plant and equipment in the first quarter of 1958 will be at the annual rate of $35,500,000,000 five per cent below indicated expenditures for the final quarter of 1957.

Δ The AAR reported that rail freight volume last week fell to 617,338 cars, 16.3 per cent below the same period of 1956.

Δ The Commerce Dept. reported that corporate dividend payments rose to $325,000,000 in November, 1957, an increase of $10,600,000 over 1956.

December 16

△ The AISI reports that the operating rate of the steel industry for the week of December 16 is scheduled at 67.9 per cent of capacity. This is equivalent to 1,739,000 tons compared with 1,770,000 tons one week ago and 2,525,000 tons one year ago. Index of production for the week is 108.3.

△ State figures showed that jobless pay claims filed by newly laid-off workers rose by 66,600 to 396,000 during the first week of December. Pennsylvania's 10,700 was the biggest increase.

△ The Labor Dept. reported that private housing starts in the first 11 months of 1957 declined to 926,700, 10 per cent under 1956.

December 17

△ In London spot copper prices climbed nearly 1¼¢ per lb, final price was 23⅛¢, up ¾¢ for the day. U. S. custom smelters boosted their price for copper ½¢, to 25½¢ per lb.

December 18

△ The Commerce Dept. reported that personal income decreased in November, 1957 to a seasonally adjusted rate of $345,500,000,000, $500,000,000 below the October pace, compared with $334,900,000,000 in November, 1956.

△ Phoenix Iron & Steel Co., subsidiary of Barium Steel Corp., closed down its Harrisburg, Pa., mill and plans to close its Phoenixville works and its Chester blast furnace division until approximately mid-January.

△ Crucible Steel Company of America announced it had acquired full ownership of Rem-Cru Titanium, Inc., from Remington Arms Co.

December 19

△ The Edison Electric Institute reported that electric power output last week climbed to 12,570,000,000 kwhr, 14,000,000,000 kwhr above the previous high attained during the week ended January 19, 1957.

△ A. M. Byers Co., reported for the fiscal year ended September 30, 1957, sales totaling $29,702,426, net earnings $566,288 or $1.04 per share; in 1956 sales were $32,286,645, net earnings $563,624 or $1.01 per share.

December 20

△ Steel scrap prices in Philadelphia advanced $3.50 a ton, to $37.00, for No. 1 heavy melting grade, attributed to buying for shipment abroad rather than pickup in demand for scrap from steel mills.

△ Railroad requested permission of ICC to file proposed higher tariffs for estimated average boosts of three per cent.

△ The board of directors of both The National Supply and Armco Steel Corp. approved in principle a proposal under which Armco would acquire The National Supply Co., and stockholders of National would receive Armco common stock on the basis of 85/100 share of Armco per share of National.

△ The ARCI reports that deliveries of new domestic freight cars in November, 1957 totaled 7,142 compared with 8,295 in October, 1957 and 6,695 in November, 1956. Orders totaled 1,070 compared with 2,206 for October, 1957 and 4,172 in November, 1956. Backlog of cars on order as of December 1 stood at 59,194 cars compared with 65,718 a month earlier.

△ Industrial Heating Equipment Assn. reports that new orders for industrial furnaces in November, 1957 were $2,832,000, compared with $3,986,000 in November, 1956; orders for induction and dielectric heating equipment in November were $770,000 compared with $1,478,000 in November, 1956.

December 23

△ Bureau of Labor Statistics announced that living costs in November, 1957 rose to 121.6 per cent of the 1947–49 average, up 0.4 per cent from October, 1957 and 3.2 per cent higher than November, 1956.

△ The Aluminum Assn. reported primary aluminum production in the United States during November, 1957 was 135,024 short tons compared with 133,759 short tons in October, 1957 and 145,081 tons in November, 1956.

△ The AISI reports that the operating rate of the steel industry for the week of December 23 is scheduled at 53.7 per cent of capacity. This is equivalent to 1,374,000 tons compared with 1,742,000 tons one week ago and 2,322,000 tons one year ago. Index of production for the week is 85.5.

December 25—Merry Xmas

December 27

△ Department of the Interior reported that mineral output in the United States attained a value of $18,300,000,000 in 1957, compared with $17,500,000,000 in 1956.

△ The AISC reports that shipments of fabricated structural steel for November, 1957 were 293,369 tons compared with 330,950 tons in October, 1957 and 276,045 tons in November, 1956. Bookings for November, 1957 amounted to 187,653 tons compared with 177,178 in October, 1957 and 338,892 tons in November, 1956. Backlog on November 30 equaled 2,563,798, a decrease of four per cent from October, 1957.

December 30

△ Commerce Dept. announced that no steel scrap export curbs will be exercised by this agency during the first quarter of 1958.

△ The AISI reports that the operating rate of the steel industry for the week of December 30 is scheduled at 59.0 per cent of capacity. This is equivalent to 1,510,000 tons compared with 1,366,000 tons one week ago and 2,490,000 tons one year ago. Index of production for the week is 94.0.

△ According to F. W. Dodge Corp. construction contracts in the United States for November, 1957 amounted to $2,370,699,000, approximately equal to November, 1956.

△ The Association of American Railroads forecasts that rail freight traffic in the first quarter of 1958 will trail the same 1957 period by 3.8 per cent. Loadings for 1957 were down approximately 6.1 per cent from 1956, and declined in the fourth quarter about 13.3 per cent.

△ The SEC reported that personal savings for the third quarter climbed to $4,700,000,000, and totaled $13,800,000,000 for the nine-month period.

△ The ICC granted permission to eleven railroads of the East to raise passenger coach fares by five per cent January 1.

△ The Bureau of Mines, U. S. Department of the Interior, reported that production of iron ore in the United States for September and August, 1957 totaled 12,932,845 and 14,370,150 long tons, respectively; shipments for these months were 13,516,361 long tons in September and 15,187,492 long tons in August.

STEEL MEN!

WHAT IS THE COST OF A "CORHART BALANCED TANK"?

•

BECAUSE Corhart Electrocast sells for several times more than ordinary clay blocks, some operators have gotten the impression that a Corhart tank costs three or four times more than an all-clay furnace.

Nothing, however, could be further from the truth. By *balancing* his furnace with the proper amount of Electrocast, the average Corhart customer adds so little to the installation cost that the difference is repaid by *a fractional part of the extra production gained.*

If you have never obtained an estimate for a Corhart Balanced Tank, (a tank with all vulnerable spots fortified by Electrocast), we believe you will be more than surprised at the low cost for which this ideal type of installation can be made . . . . Send us the plans of your furnace, with a brief description of its past history. Using the experience gained in designing 65 Corhart Balanced Tanks, we will gladly recommend the amount and location of Electrocast needed to *balance* your furnace, and submit for your consideration complete blue-prints and quotations . . . . This service will cost you nothing, but it will probably prove the most interesting reading of the year. No obligation—and no high-pressure "follow-up." *Address:* Corhart Refractories Co., Incorporated, 16th and Lee Streets, Louisville, Kentucky.

QUALITY ECONOMY ENDURANCE

CORHART ELECTROCAST REFRACTORIES

WE RAN this ad for a Corhart Electrocast Refractory a little over 25 years ago—back when only a handful of glass manufacturers would think of using this new product, "one of the world's highest-priced refractories". Yet today virtually every furnace in the glass industry uses Corhart Electrocast . . .

Today Corhart 104 is new in the steel industry. And although it too is "one of the world's highest-priced refractories", it offers open-hearth furnace operators the same opportunties for greater production and lower costs that Corhart Electrocast brought to the glass industry.

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QUALITY ECONOMY ENDURANCE

CORHART 104 ELECTROCAST REFRACTORY

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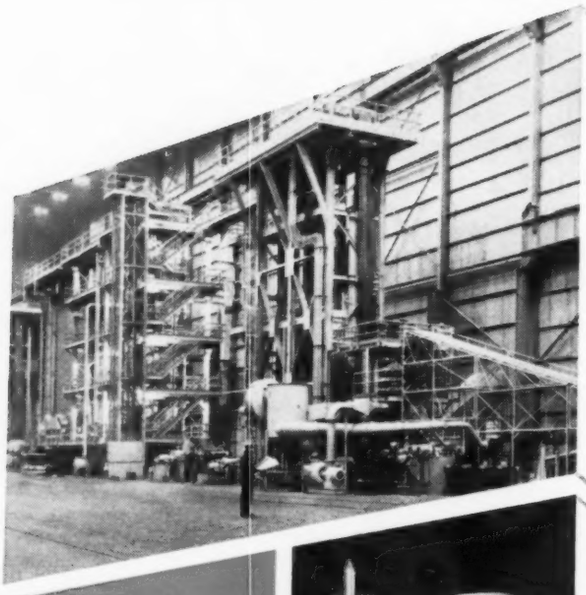
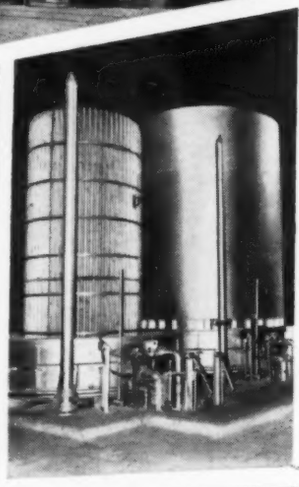
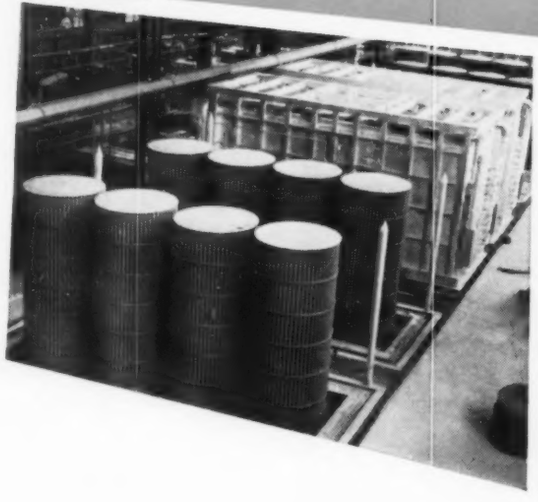


VERTICAL STRIP ANNEALER



SINGLE-STAND ANNEALERS

CONTINUOUS STRIP GALVANIZER



MULTIPLE-STAND ANNEALERS

foundation for steel mill profits

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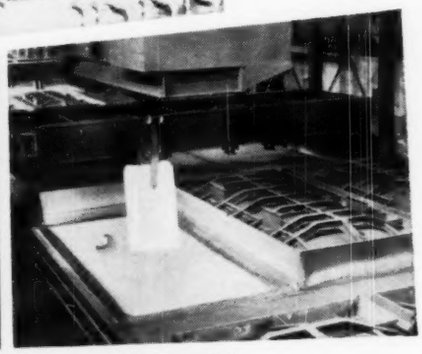
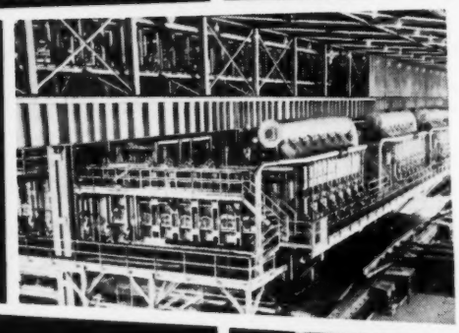


ONE-WAY FIRED SOAKING PITS



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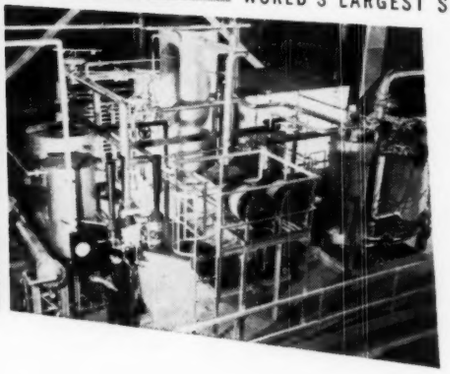

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You put a solid foundation under your profits whenever you specify Surface equipment. Whatever type it may be, you know it is supported by many interlocked blocks of know-how in heating and handling steel.

The technical skills which Surface has developed in building soaking pits will benefit the man who buys Surface annealing covers. In the same way, Surface concepts of slab heating contribute to high-speed stress relieving . . . carbon restoration to strip annealing . . . controlled atmospheres to wire patenting.

Because of this broad and deep foundation of experience, Surface can improve any single process in the context of a complete sequence of operations. This is to the customer's profit, as many companies will confirm.

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wherever heat is used in industry

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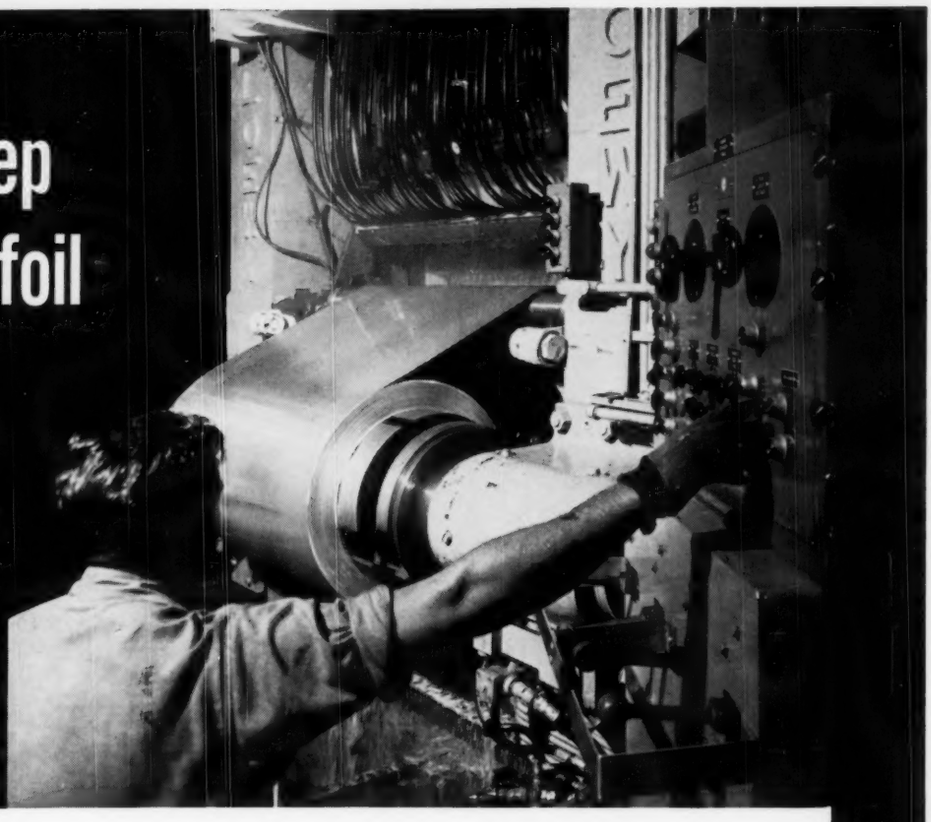
Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes

how to keep aluminum foil from shattering

... at 35 miles per hour!



Kaiser Aluminum & Chemical Corp. increased annual production of aluminum foil 50% at its Permanente, California plant through installation of a four high foil mill. This mill reduces aluminum strip in thickness from .026 to .00025 of an inch at speeds up to 3000 fpm.

At 35 miles per hour, excessive strain at any of the several reduction stages would shatter the extremely thin foil. From the original payoff reel through to the final rewind, uniform tension is provided by Reliance V★S Drives.

Reliance engineers built this drive specifically for this mill, to provide the constant uniform tension which is so important.

This application is typical of the many diversified jobs that Reliance V★S Drives are called upon to perform. There is a Reliance V★S Drive to fit your application.

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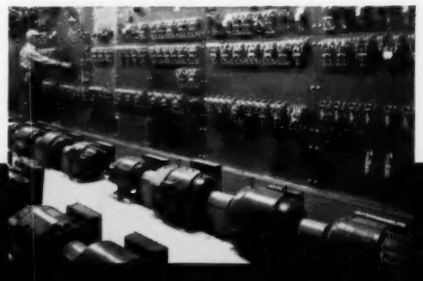
For further details, write **Dept. 111-A**



Main control room—Where Reliance equipment provides more than 2,900 hp. to drive this mill.

RELIANCE ELECTRIC AND ENGINEERING CO.

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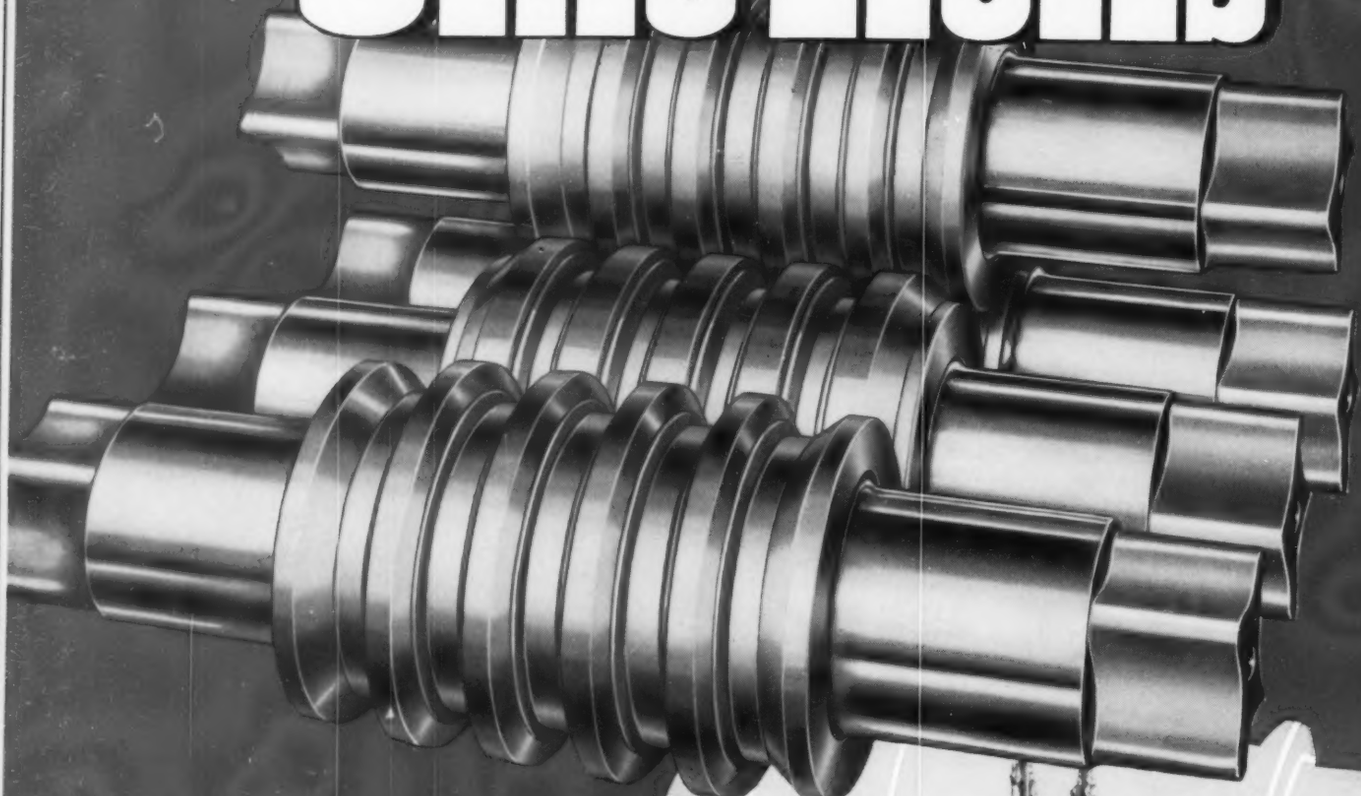

Ohio Iron and Steel Rolls

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OH19

Industry News...

JONES & LAUGHLIN ANNOUNCES PROGRAM FOR NEW STAINLESS STEEL PLANT AT LOUISVILLE, KY.

△ More than $16,000,000 will be spent by Jones & Laughlin Steel Corp. for plant and equipment at its new stainless steel sheet and strip mill now under construction at Louisville, Ky.

With operations scheduled to begin in the third quarter of 1958, the new facilities will be housed in renovated and new buildings on the site of the old Superior Sheet Steel Co., and will be able to produce annually about 36,000 net tons of stainless steel sheet and strip with a gage range from 0.012 to 0.005 in.

The company is installing a high-speed Sendzimir cold rolling mill, a continuous annealing and pickling line for cold rolled sheet, a coil preparation line for incoming hot rolled sheet, a 54-in. temper mill, three side strip and slitting lines, two shear-to-length lines for cutting coils into sheets, and an inspection line for surface check and recoiling. Other equipment includes polishers, grinders, and materials handling equipment. A new building will house offices and a metallurgical laboratory.

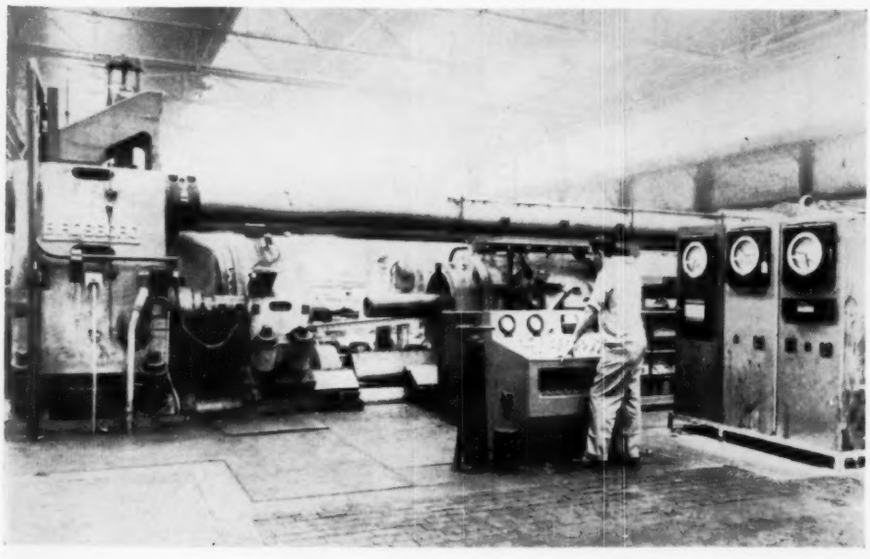
Louisville was selected as the plant location because of its ample water, power and sewerage facilities, its excellent rail and highway outlets, the availability of a plant site, and because of the community's manpower and tax climate.

J&L's Stainless Steel Division, producing ingots, slabs, blooms, billets, bars and wire, will supply the raw materials for the Louisville plant when the latter goes into operation.

The Louisville plant site was obtained from the Louis Berkman Co. of Steubenville last summer. Renovation and expansion now are well under way.

AUTOMATIC WATER-HYDRAULIC PRESS IN OPERATION

First automatically sequenced water-hydraulic extrusion press in this country is now in operation at Kaiser Aluminum & Chemical Corp., Halethorpe, Md. It was designed and built by Birdsboro Steel Foundry & Machine Co., to extrude a broad range of aluminum tube sizes and assorted shapes. A principal feature of the machine is its built-in automatic cycle control for the movement of the main moving crosshead. This system, employing a water operated oil hydraulic servo arrangement, controls the main ram fast advance—the extrusion stroke—and the return stroke to starting position. All elements of the press are automatically controlled through the entire extrusion cycle by two simple electrical circuits which energize and de-energize solenoid operated valves through limit switches. These, in turn, actuate the larger hydraulic valves and set various parts of the machinery into action.



TO IMPROVE FACILITIES AT NORTHEASTERN PLANT

△ The Carpenter Steel Co. may invest up to $6,500,000 in its newly acquired subsidiary, Carpenter Steel of New England, Inc. According to Frank R. Palmer, president of both companies, the exact amount to be spent on the former Northeastern Steel mill will depend on market potential, customer requirements, cost of local services and supplies, and other factors now under study.

"We intend to invest whatever is necessary to meet the needs of steel users in the New England and metropolitan New York areas," Mr. Palmer declared. "Naturally, I mean their need for the types of steel we will produce here—electric furnace quality stainless and alloy steels."

Carpenter will have to install additional machinery, including in-process inspection equipment to achieve a high level of quality in the finished steels. The company will also have to make a substantial investment in inventories and other working capital.

Considerable work, as well as money, will be required to place the local plant on a profitable basis. The job might take two years, Mr. Palmer stated, depending on the economic cycle.

"In one respect, our acquisition of the Northeastern Steel Corp. comes at a good time," he remarked. "Most of our customers are now liquidating inventory and buying steels at a lower rate than their actual usage. This permits us to take whatever time is needed to put the plant into good working order without excessive pressure for quick delivery of the mill's output.

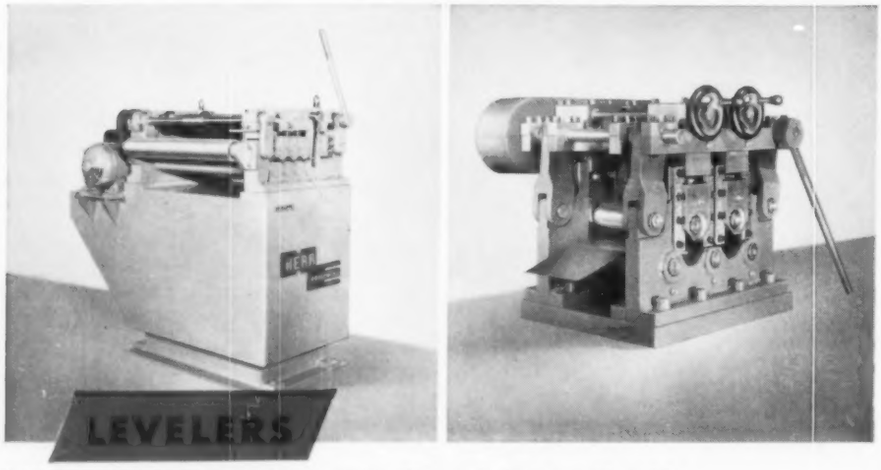
DIESEL TOWBOAT HAS STAINLESS STEEL HULL

△ A steel-hulled diesel towboat was added to U. S. Steel's river fleet when the *H. B. Jordan* was put into active service last month.

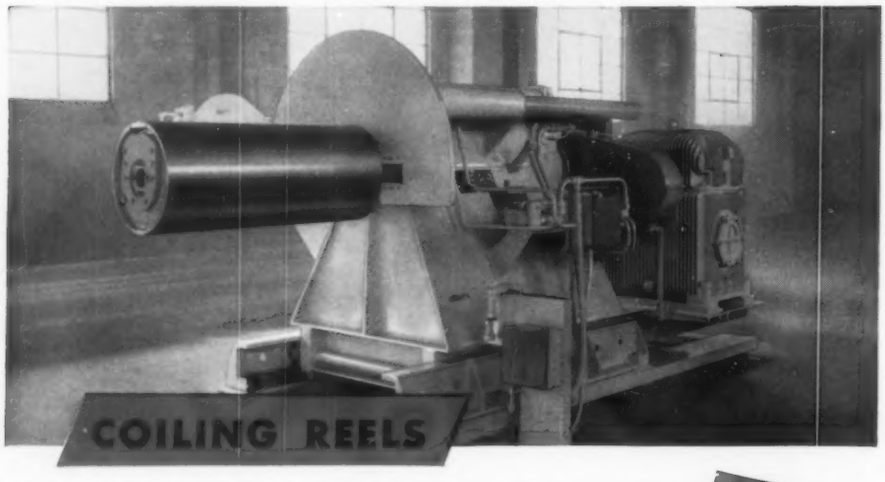
This marks the first time that this

HERR EQUIPMENT

"Complete Processing and Handling Equipment . . . for any Ferrous or Non-Ferrous Material . . . That Starts — or Ends — as a Coil"



2-High and 4-High types. Driven and pull-through designs with quick release, for handling an extremely wide range of materials, widths and gauges. Rolls can be rubber covered if desired for easier adjustment and handling high finished materials.



Wide variety of types and sizes for coiling ferrous and non-ferrous strip. Fixed, adjustable or automatically aligning bases. Automatic oscillating level winding drive if desired. Link type contracting mandrels; manually or hydraulically operated. Furnished complete ready for use.

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THE HERR EQUIPMENT CORPORATION

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CLEVELAND, INDIANAPOLIS AND BERKELEY, CALIFORNIA

corrosion-resistant steel has been used in the hull construction of an inland waterway towing vessel—largest of its kind ever built. All parts exposed to water from the main deck down are of stainless steel.

The 120-ft long craft was christened after Harvey B. Jordan, U. S. Steel executive vice president—operations. Designed and built for U. S. Steel by the St. Louis Shipbuilding and Steel Company, the craft has a 27-ft beam, measures 9 ft in depth with a draft of 6½ ft.

Approximately 40 tons of stainless steel hull plating were used in construction of the vessel, welded by stainless steel rods. Nearly eight tons of stainless steel forgings and castings were used. The scow bow is stainless as well as the stern tubes and struts. The two 4-blade, 80-in. diam propellers also are stainless steel, as are the propeller shafts. The rudder, as well as the two inboard sea-chest compartments, likewise are of stainless steel.

WESTINGHOUSE AWARDED MEXICAN MILL CONTRACT

△ Cia. Fundidora de Ferro y Acero de Monterrey, S.A., Mexico's oldest steel mill, has placed a $5,000,000 order with Westinghouse Electric International Co. for electrical equipment to power the firm's new flat products mill.

Scheduled to begin operation later this year, the plant is being set up by Fundidora partly through a newly-formed subsidiary, Aceros Planos de Monterrey, as part of a $65 million modernization and expansion program. According to R. D. McManigal, sales vice president of Westinghouse International, the equipment order includes main drives and auxiliaries for a 66-in. hot strip finishing mill, a four-high reversing cold mill and skin pass mills for hot and cold rolled strip. In addition, two 2000 hp motors will power a three-high billet mill.

Fundidora has concentrated in the past on the production of bar products for the building and railroad industries. Through Aceros Planos it will provide flat products for use in furniture, appliances and building to meet demands increasing about 20 per cent annually.

Mexico's steel requirements are climbing each year at the rate of

Tomorrow's products today...from NATIONAL CARBON Research

The biggest carbon electrode ever made — shown in one of National Carbon Company's electrode plants, Niagara Falls, N. Y.

Now NATIONAL electrodes
TRADE-MARK

up to 60" in diameter!

This 10 ton, 60" diameter "National" electrode is larger than existing furnaces require. But on drawing boards now are submerged arc furnaces rated at over 50,000 kilovolt-amperes. They'll need giant electrodes to perform successfully.

By anticipating industry's needs, National Carbon meets customers' requirements with fully developed products. One more reason to specify "NATIONAL" ELECTRODES, product of the nation's foremost electrode producer.

NATIONAL CARBON gives furnace operators...

- ☆ **Highest uniform electrode quality**
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The Red Circle on the Roll is the Hyde Park mark of Quality. Hyde Park makes rolls for every type mill.

CHILLED ROLLS · ALLOY IRON ROLLS · MOLY ROLLS · NICKEL CHILLED ROLLS · GRAIN ROLLS · COLD ROLLS · SAND ROLLS

for
Finer Finish, Longer Life
and Greater Tonnage
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ROLLS
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3.08 lb per capita, according to Manuel Noriega, Fundidora's assistant manager and United States representative. Last year, he pointed out, the Mexican steel industry produced 700,000 tons of the 1.1 million tons of finished products required. By 1965 the country's needs are expected to reach 2 million tons.

Establishment of Aceros Planos and the new finishing mill climaxes a ten-year development program by Fundidora which included modernization of mining operations on the Cerro de Mercado "iron mountain" at Durango. The company plans to enlarge its basic capacity to one million ingots annually with the addition of new blast furnaces and seven open-hearth furnaces. Ingot production next year is expected to be about 400,000 tons.

NEW J&L COLD MILL OPERATING AT CLEVELAND

△ Jones & Laughlin Steel Corp. has placed in operation one of the steel industry's fastest four-stand cold reducing mills for sheet steel at the Cleveland, Ohio, works.

This mill, installed at a cost of $10,000,000, makes possible a production of 70,000 tons of sheet per month. This tonnage is about double the capacity of the mill it replaces.

The mill is a 77-in., four stand, four-high rolling mill. It consists of four mill stands spaced closely together in one continuous line. Each of the four stands contains two work rolls and two backup rolls arranged vertically. The larger backup rolls are used to reinforce the smaller working rolls. This use resists the tendency of long working rolls to deflect, and permits the use of smaller diameter working rolls for producing wide sheets of uniform thickness.

Maximum speed of the new mill is 3800 fpm. It can produce sheet up to 72 in. in width. Sheet may be reduced by two-thirds (60 to 70 per cent reduction) of its initial thickness. Present production ranges from 0.0179 of an in. to 0.0747 of an in. (26 to 14 gage).

The mill was designed and built by E. W. Bliss Co., and erected by Ragnar-Benson Inc., Pittsburgh. All piping and facilities for handling lubricants, coolants, hydraulic oil, air, and steam were engineered and installed by the Power Piping and

CM HERC-ALLOY®

...the original alloy steel chain

TO SERVE YOU BETTER: Herc-Alloy chain assemblies can now be ordered with either of two types of coupling links.

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...the "do-it-yourself" reusable coupling link that enables you to assemble or rebuild your own Herc-Alloy sling chains with all components furnished by your local distributor.

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Sprinkler Division of Blaw-Knox Co. Electric drive equipment was furnished by General Electric Co., and installed by Dingle-Clark Co.

The completion of this mill ties in with other modernization of J&L's Cleveland Works. A new blooming mill and reversing rougher for the hot strip mill will provide hot mill coils with weights up to 18,000 lb for the new cold reducing mill.

Coils weighing up to 60,000 lb can be formed in the continuous pickling lines and run through the new mill. These will make as much as three miles of continuous sheet in the thinner gages and narrower widths.

Almost 23,000 horsepower, believed to be the greatest in the steel industry for four-stand cold reducing mills, is available from ten electric motors that drive the mill.

Among the features of the mill are the independent electric motors, each with a separate generator, for driving each of the eight work rolls in the four stands. This feature reduces and simplifies the drive mechanisms by eliminating pinion stands and by reducing the size of the reduction gearing.

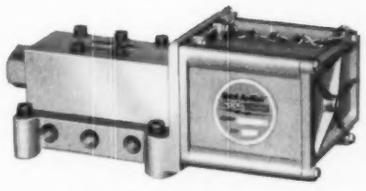
Automatic control of the thickness of the sheet produced is another feature of the mill. This is done by means of an x-ray type gage on the delivery end of the fourth stand. The gage provides a signal used in controlling speeds of the motors that drive the mill rolls.

The heat generated in the mill rolls by the cold rolling process is dissipated by a recirculating flow of 2,500 gal of oil and water emulsion per minute. A total of 5,000 gal of water per minute is supplied by a recirculating system to cool this emulsion, the mill lubricants and the ventilating air for the electrical equipment. The recirculating water is cooled in a forced draft cooling tower.

RECEIVES CONTRACT FOR ORE HANDLING SYSTEM

△ An order amounting to more than $5,500,000 has been received by Hewitt-Robins, Inc. for the construction of a material handling system at a new iron ore mine atop a 2,600-ft mountain at Barsua, Orissa Province, India, 225 miles southwest of Calcutta.

Quick-As-Wink®
AIR AND HYDRAULIC
Control Valves



¼" "O"-Type Single Solenoid 4-way Valve.

½" "B"-Type Lever Operated 4-way Valve.

Play safe. Install Quick-As-Wink valves on **all** your air and hydraulic controls. Positive and fast acting, all operating parts are in pressure balance, avoiding any tendency to creep or crawl. You'll get month after month and year after year of long, dependable, trouble-free — **and safe** — service. There's nothing better than a Quick-As-Wink Control Valve. Can you afford to gamble with less? Sizes from ¼" to 4". Hand, foot, cam, pilot, diaphragm or solenoid operated. Thousands of different types, sizes and actions. Get full details.

Write for **BULLETIN NO. 571** *Today.*

Quick-As-Wink®
AIR AND HYDRAULIC
Control Valves

Mfd. by **C. B. HUNT & SON, INC., 1924 East Pershing St., Salem, Ohio**
—Engineering and Sales Representatives in the Principal Cities—

The order calls for the design, fabrication and erection of a two-mile conveyor system and related crushing, screening and storage facilities that will take the ore as it comes from the mine, process it to specifications, then load it into railroad cars for shipment to the steel plant at Rourkela 45 miles away.

The new mine is located in a dense bamboo jungle. The deposit covers an area about 35 miles long and a mile wide containing an estimated 150,000,000 tons of ore. The iron content ranges from 54 to 65 per cent, roughly comparable to the best ore mined on the Mesabi range. Construction of the mine facilities is to be started immediately and completion is scheduled for December, 1959.

Here is how the material handling system will work:

Ore weighing 150 lb per cu ft will be excavated by electric power shovels and trucked to a crushing station which will be built near the mountain peak at an altitude of 2,600 ft. Crushers will reduce all oversize lumps to 3¼-in. diam in preparation for transfer to the conveyors which will carry the ore down the mountain to a screening station located at an altitude of 1300 ft.

Five conveyors totaling 9,500 ft in length will be linked together in a continuous system to carry the ore at a rate of 700 long tons per hr from the crushing station down to the screening station. The conveyors will actually drive the motors once the load starts moving, causing the motors to act as generators. Operating in this fashion, the motors will generate approximately 800 hp of electricity that will be fed to the crushers and other equipment. A unique drive and braking mechanism developed by Hewitt-Robins engineers will be used to control the descent of the conveyors so that they will run evenly at all times and will not run away under their heavy load.

At the screening station, all ore will be classified so that lump size will range from ½ in. to 3¼ in. All ore under ½ in. will be diverted to a storage pile, to be held indefinitely until a future sintering plant is built which will agglomerate the fines into lumps large enough to be suitable for blast furnace feed. The ore to be shipped will be loaded aboard rail cars which will arrive and depart in 20-car trains, hauling approximately 6,000 long tons daily to the steel mill.

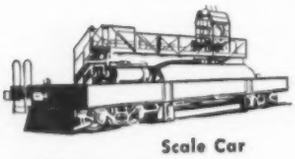
In addition to the conveyor system, on the mountain side, the project will involve additional conveyor units required to move the ore at the crushing and screening stations, and the railroad loading facility. All conveyors will have a combined length of 12,150 ft.

The new contract is the largest Hewitt-Robins has ever received, and is unusual also in that it provides for a "turnkey" job.

FOUR ENGINEERS SHARE MILL CONTROL AWARD

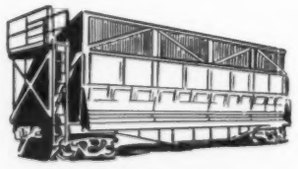
△ Four Westinghouse Electric Corp. engineers have received $2,500 each for developing a control system that permits production of strip steel at speeds in excess of a mile a minute. The special awards were presented at the company's East Pittsburgh plant by A. C. Monteith, vice president, apparatus products. William A. Steiger, general patent counsel, cited the award recipients

WHEREVER *performance* COUNTS



Scale Car

100-ton Ore Transfer Double Compartment, Bottom Dump



Coke Quenching Car

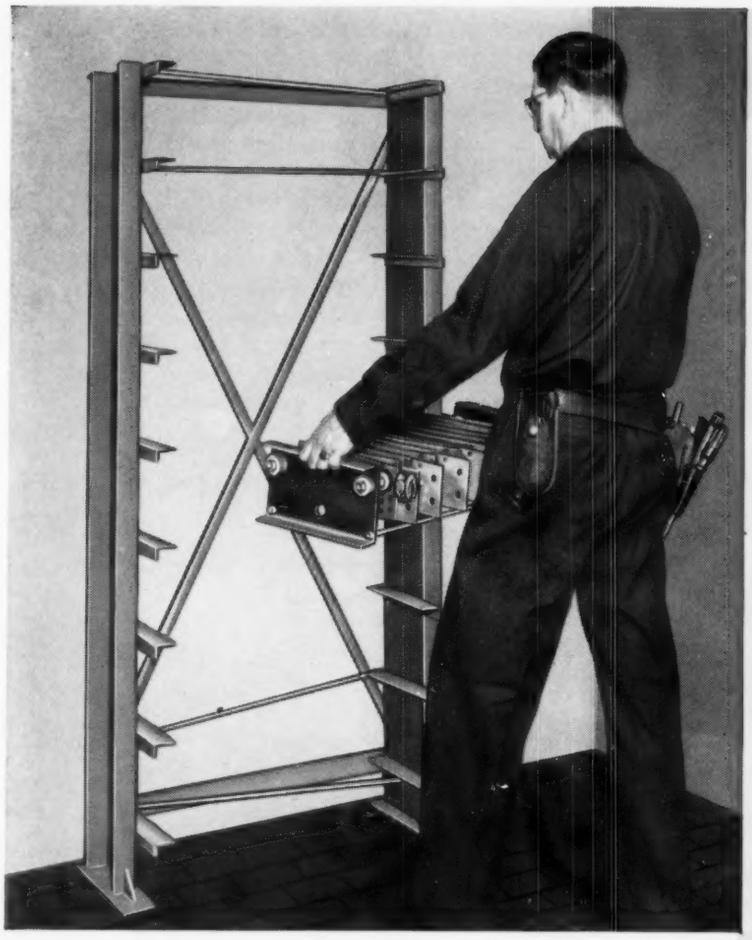
Atlas Cars are built to resist the high wear factors of continuous service handling abrasive materials. Extra factors of safety in brakes, controls, visibility, and signal devices are incorporated for foolproof service.

Each car is engineered to meet the operating needs of the plant where it will be used.

ATLAS
CAR & MFG. CO.
1100 IVANHOE ROAD
CLEVELAND 10, OHIO

Consult Atlas for your Steel Plant Cars

ENGINEERS AND MANUFACTURERS SINCE 1896



NEW EC&M UNI-STACK

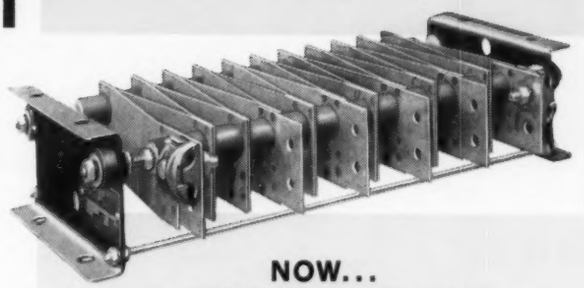
Self-Standing

Industry's First RESISTOR MOUNT

EC&M's new **UNI-STACK** means significant savings because it's self-standing, and can be mounted in position before resistor sections are installed. **UNI-STACK**'s lighter weight makes it easier to handle, quicker to install. Individual sections then can be slipped into place easily.

Only two front bolts are required to hold individual **TAB-WELD*** resistor sections in place. Resistor terminals are located at the front for quick connection to either cable or bus. **UNI-STACKS** are available in seven sizes for mounting from three to nine EC&M **TAB-WELD** standard mill sections.

*Registered Trade Mark of EC&M



NOW...
up to 500 Amperes Continuous

• EC&M **TAB-WELD** resistor sections are now available in capacities from 13 to 500 amperes continuous rating. Sections are mill-type with the same grid size throughout and supplied with clamp terminals. EC&M **TAB-WELD** construction eliminates burning at the grid-eyes and at tap-plates.

For convenience, space savings, and lower costs, specify the perfect combination—EC&M TAB-WELD Resistors and EC&M UNI-STACKS

THE ELECTRIC CONTROLLER & MFG. CO.
A DIVISION OF THE SQUARE D COMPANY
CLEVELAND 28 • OHIO

9696

for "creative, inventive thinking which has produced an outstanding invention."

Those honored were Raymond W. Moore, William D. King, James T. Carleton and Loren F. Stringer. The control system invented and patented by the Westinghouse team is based on use of magnetic amplifiers which in effect reduce duration of control reactions from four seconds to one-tenth of a second.

In addition to split-second response to load variations, the system is said to demonstrate higher regulating accuracy than any previous control method. Its speed, reliability, and accuracy have permitted higher rolling speeds on tandem cold reduction mills.

These mills receive cold steel strip about $\frac{1}{10}$ in. thick and in a series of four or five passes reduce the thickness to about $\frac{1}{100}$ in.

In reviewing the development of cold reduction mill processes, Mr. Monteith noted that in 1928 the first such mill installation had a top speed of 340 fpm. By 1936 top speeds had jumped to 1500 fpm.

In 1945 Westinghouse engineers conceived a method of control that permitted close speed regulation at speeds of several thousand feet per minute. However, Mr. Monteith said, it was foreseen that a radically new means of control was necessary to meet demands for still higher mill speeds. Developed to meet this need, the new system permits speeds of better than 6000 fpm.

SAVE downtime for bearing replacement

use A·B·K* bearings

A-B-K bearings won't peen, score or heat check your heavy roll and spindle parts, sharply reduce downtime and maintenance costs per ton rolled. Made of laminated phenolic fabric, they have the ability to absorb and cushion heavier impacts—and often outwear metal bearings many times. When replacements *are* necessary, downtime is reduced because A-B-K bearings have fewer parts, are lighter in weight, easier to handle. Ask our engineers for specific recommendations.

- Wear longer
- Won't score
- Light in weight
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LAMINATED
PHENOLIC BEARINGS

A registered trade-mark of Amer can Brake Shoe Company

American Brake Shoe
American Brakeblok Division
DETROIT 9, MICHIGAN

PRECIPITATOR UNIT READIED FOR McLOUTH

△ The Metal Products Division of Koppers Co., Inc., has completed design for a double-chamber, single-field electrostatic precipitator for installation early this year at the Trenton, Mich., plant of McLouth Steel Co. Fabrication of the unit, purchased for McLouth by Dravo Corp., is now in progress at the Koppers plant in Baltimore, Md.

The precipitator, together with a mechanical collector, will clean gas emanating from an iron ore sintering machine. The combination has been designed to give approximately 98 per cent efficiency when handling 200,000 cu ft of gas per minute at 350 F.

The precipitator will be energized by a vacuum tube power unit.

BEGINS TRIAL RUNS ON COMBINATION MILL

△ Keystone Steel & Wire Co. has begun trial production runs of its new combination rod and bar mill, according to an announcement by company president and general manager, R. E. Sommer.

Under construction since 1955, the high speed rolling facilities will eventually more than double the firm's production capacity for rods. In addition, the new mill increases the range of steel rod sizes, enables precision rolling of rods to closer tolerances and provides for manufacture of bar steel in coils, a new major product in the company's industrial line.

The mill will be operated by employees transferred from Keystone's other rod mill. Thus, no immediate additional employment for operation of the new mill is foreseen. Supervision of the new mill will be

under rolling mills superintendent William Herman; William Dawson, formerly with American Steel and Wire Division, U. S. Steel Corp., will be general foreman of the mill.

"Completion of this mill begins a new era of growth for Keystone," commented Mr. Sommer. "Not only will we be able to serve present customers with a more complete range of steel products, but in addition we will be capable of serving a completely new field of customers who purchase precision rolled bars for cold heading and other uses."

During initial months of the mill's operation, it will produce only larger rod sizes, some of which were not available from the first mill. After April, it will produce rods in a wider size range as well as bars up to one inch in diameter.

Besides the rod and bar mill, other major developments in the company's recent expansion program to produce steel in semi-finished forms include redesign of its four open hearth steelmaking furnaces, additional ingot reheating furnaces, automatic billet shearing and cooling equipment to provide additional steel for rod and bar rolling. Other major recent improvements and additions include new warehousing, power plant improvements, increased space for maintenance, wire drawing and nail departments, and new facilities for production of special processed wire for cold-heading customers.

Expansion and modernization activity will continue in 1958. Already underway is a new fifth open hearth furnace which will raise the company's ingot steelmaking capacity to 620,000 net tons per year. The blooming mill will be completely modernized, and a new industrial wire storage building will be constructed during the year.

SOUTH AFRICAN FURNACE CONTRACT GIVEN LOFTUS

△ Loftus Engineering Corp. has been awarded several contracts for increasing the rolling capacity at the South African Iron and Steel Industrial Corp., Ltd., Iscor Works, located at Vanderbijl Park, Transvaal, South Africa, near Johannesburg. In addition to a contract for the design and construction of a completely new triple fired continuous slab reheating furnace, Loftus will redesign the firm's two existing furnaces of this type.

The slab reheating furnace is to be equipped with a metallic recuperator. Cold slabs ranging in size from 3 in. to 7½ in. thick will be heated to rolling temperature at a maximum rate of 130 tons per hr. It will be a three zone furnace equipped with four banks of burners. Fuel will be mixed blast furnace and coke oven gas having a calorific value of 300 to 330 BTU per cu ft.

The two existing continuous slab reheating furnaces will be altered to increase their present capacity and to burn mixed coke oven and blast furnace gas. Also, new metal recuperators will replace the present refractory type recuperators.

Meetings

△ Ninety-five authors will present 63 papers at the annual National Spring Meeting of the American Welding Society, which will be held at the Hotel Statler, St. Louis, Mo., April 14–18. The meeting will be held in conjunction with the Welding Show.

Twenty-one sessions covering various aspects of welding will be conducted, with three papers read at each.

for intense concentration of heat...

The BLOOM HTR BURNER

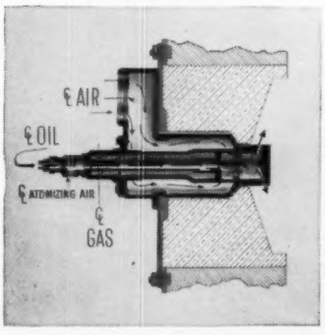
The Bloom HTR Burner provides identical operation on either gas or oil.

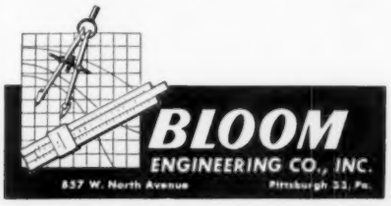
This burner enables the engineer to design a heat pattern with excellent results, because it has the unique characteristic of providing localized high heat release with low forward velocity. The burner can be located to fire directly at the material without flame impingement. Roof firing is easily accomplished and provides uniform hearth temperature.

This burner has been very successful in its application to tube upset furnaces; continuous strip annealing, coating, and pre-heating lines; high speed billet heating furnaces; and batch-type forge furnaces.

The Bloom High Thermal Release Burner with its sturdy construction is ideal for applications requiring speed and precision heating.

PATENT PENDING



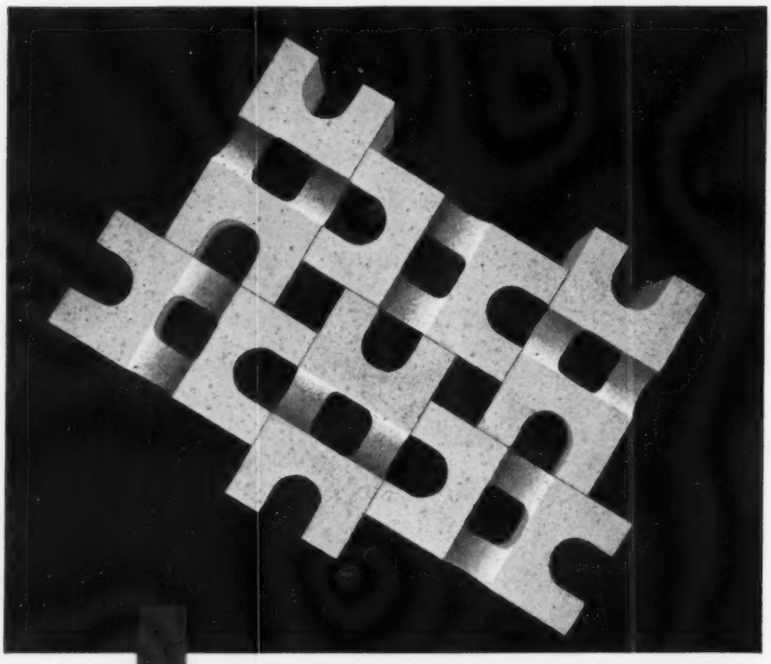


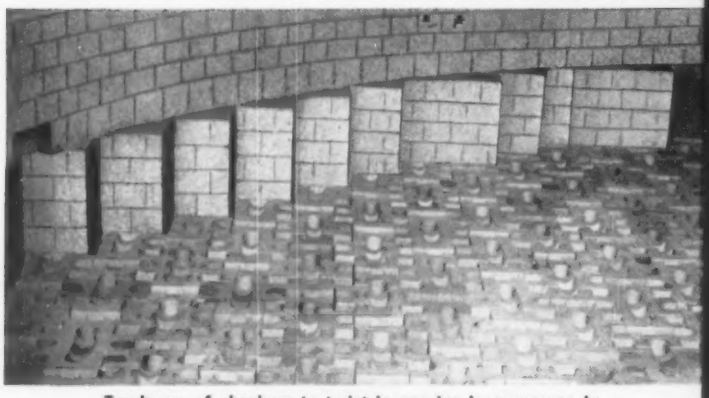
New design provides

25% to 50%

GREATER HEATING SURFACE

than ordinary basket weave checkers



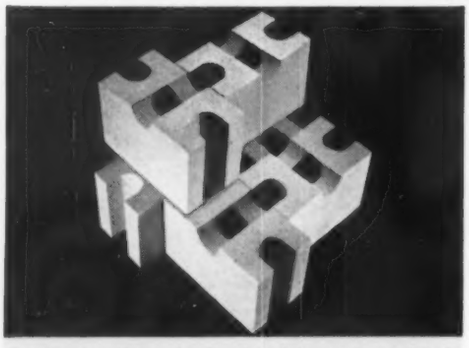


Tendency of checkers to twist in service is overcome by pilaster wall construction of the Bailey Hot Blast Stove.

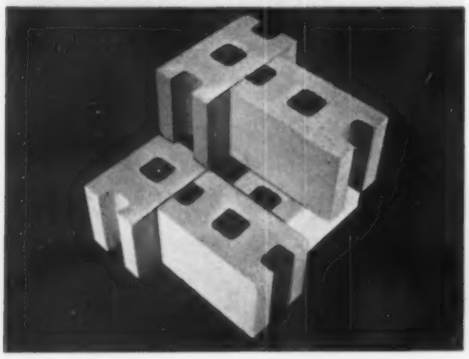
KENNEDY

BLAST FURNACE STOVE

CHECKERS



The regular Kennedy Checker (above) is of 3-hole design with unobstructed flue openings, 1¼" minimum wall thickness and a cross flue. It also can be furnished (below) without the cross flue feature.



This new 3-hole checker shape is laid in basket weave style to produce a solid 1¼" wall between each flue. This assures greatly increased heating surface without sacrificing the advantages of basket weave design.

The increased heating surface of the Kennedy Checker results in a correspondingly lower stack temperature. This makes possible the use of a modern steel bottom for supporting the checker system.

Write for Bulletin

WILLIAM M. **Bailey** COMPANY

ENGINEERS

LEADERSHIP THROUGH QUALITY

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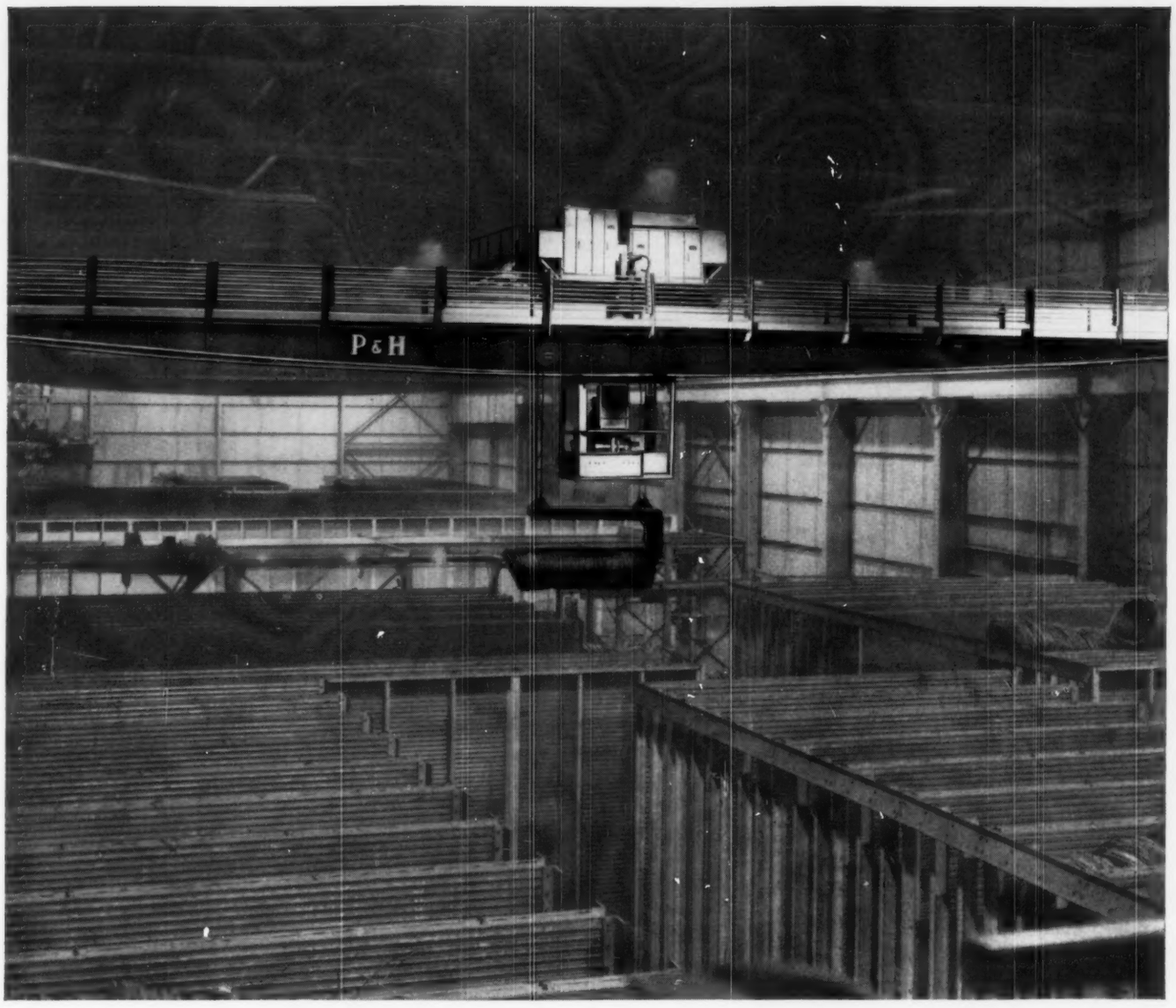

You are looking at a high-production tool!

Overhead cranes in steel mills must provide steady service and speedy handling of materials to maintain a smooth flow of production. And you get *more* of both with P&H "mill-type" overhead cranes . . . rugged units that are engineered mechanically, structurally, and electrically to provide uninterrupted duty cycles in steel mill service.

P&H cranes are built to enable operators to lift and move giant loads quickly . . . to spot them accurately and safely with finger-tip ease. The results: top performance, less wear and maintenance, and uninterrupted material flow.

Remember, too . . . P&H designs and builds all the parts for P&H cranes and provides service by skilled technicians wherever, whenever needed.

You know you can rely on P&H experience, engineering, and advanced overhead crane design. Thus it is wise to consult P&H first. For more information write Dept. 131G, Harnischfeger Corporation, Milwaukee 46, Wisconsin.

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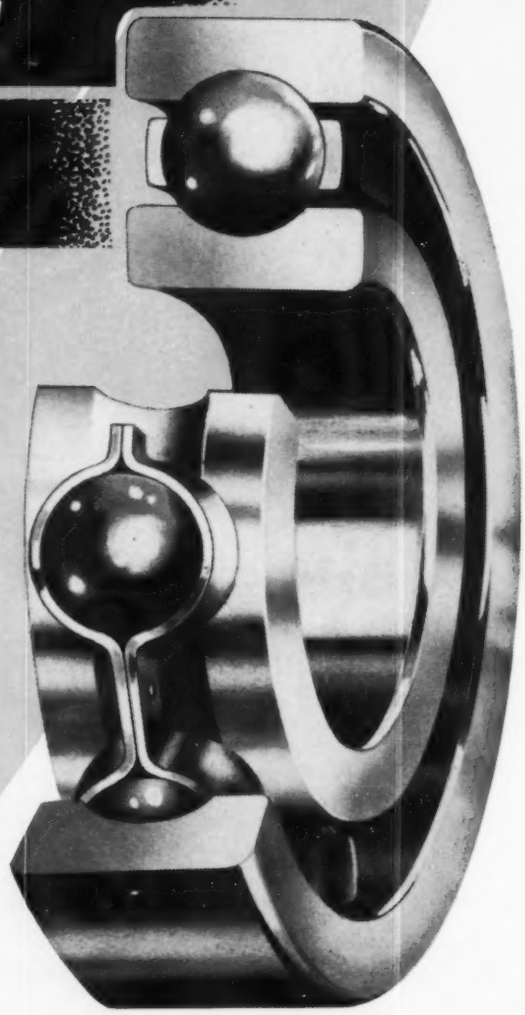
P&H ... quality and service for 74 years

37 years of IMMEDIATE DELIVERY



Away back in 1920, when Berry Bearing Company was founded, the new company established a basic policy of *immediate delivery* on *every order*, large or small.

In those days, when a customer phoned a bearing distributor and ordered a bearing, the customary reply was--"Come and get it"--*if* the bearing was in stock, which all too frequently was not the case.

In contrast, Berry startled customers and competition alike by replying--"We've got it...and...we'll make delivery immediately. Obviously, having the bearing in stock and being eager to make immediate delivery on all orders offered bearing users two outstanding advantages which promptly attracted customers and started the new company on its way to success.

For 37 years Berry Bearing Company has maintained its original basic policy of--immediate delivery on every order, large or small. Today, Berry Bearing is one of the largest bearing distributors in the United States...and...is authorized stock-carrying distributor for 41 of the nation's leading manufacturers of bearings, bearing specialties, and transmission appliances.

Thus, with an inventory of over 50,000 items regularly in stock, Berry can supply you with *anything* you need. And, as usual, you'll get immediate delivery on every order, large or small.

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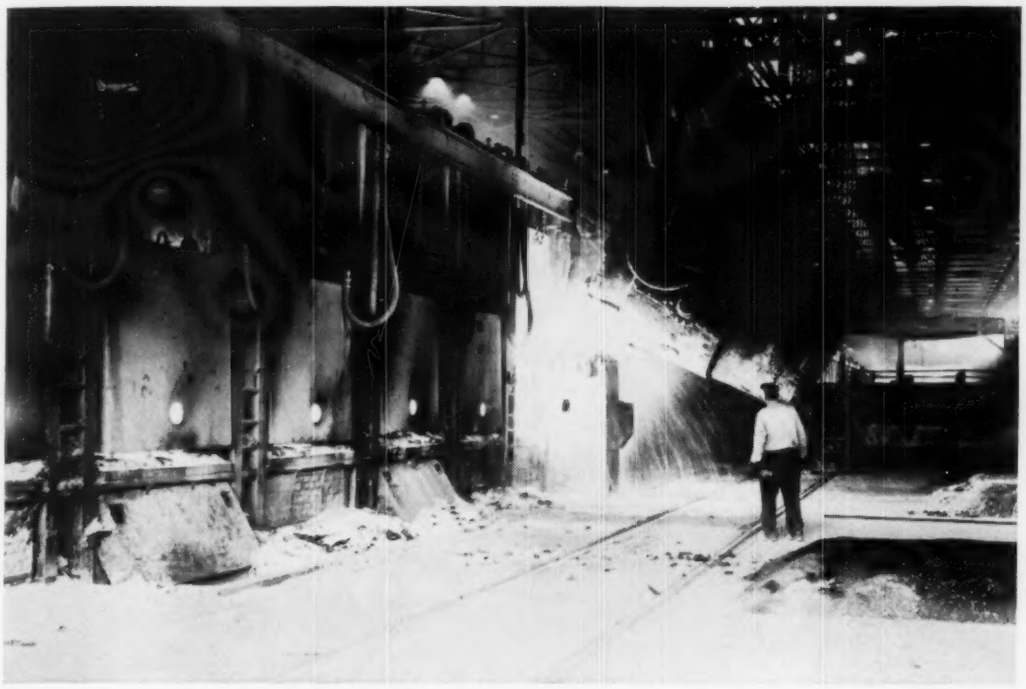
Combustion Controls by ***ASKANIA***

600-ton open hearth furnace for Weirton Steel Company, Division of National Steel Corporation

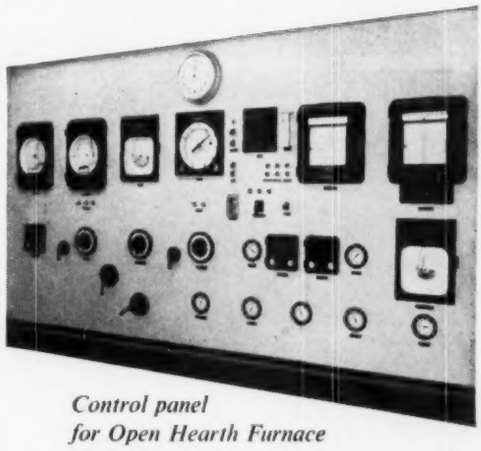


View of famous open hearth furnace at Weirton Steel Company plant, Weirton, W. Va., which utilizes ASKANIA Fuel/Air Ratio and Furnace Pressure Controls

Accurate, Dependable Askania Furnace Pressure and Combustion Controls are Easily Maintained

The largest open hearth furnace in the world was put into operation at Weirton Steel Company, Division of National Steel Corporation, Weirton, W. Va., late in 1956. This furnace has a rated capacity of 600 tons...is approximately 111 feet long by 30 feet wide...was built by Loftus Engineering Corporation, Pittsburgh, Pa.

Askania Regulator Company is proud to have its controls selected for this outstanding open hearth. They are daily proving their effectiveness in the control of furnace pressure and combustion by precisely maintaining prescribed operating conditions.



Control panel for Open Hearth Furnace shown above

If you are looking for combustion controls which can be depended upon to

1. Maintain ideal furnace operating conditions
2. Hold maximum production levels
3. Require the minimum amount of attention and the least maintenance—

you can rely upon ASKANIA controls with the exclusive Jet Pipe principle.

The Askania Regulator Company produces a complete line of blast furnace, open hearth, soaking pit and other steel mill controls.

For descriptive literature providing detailed information on Askania controls, write to Askania Regulator Company, 246 E. Ontario St., Chicago, Ill.

ASKANIA REGULATOR COMPANY
"CONTROLS FOR INDUSTRY"
Hydraulic, Electrohydraulic and Electronic Controls—
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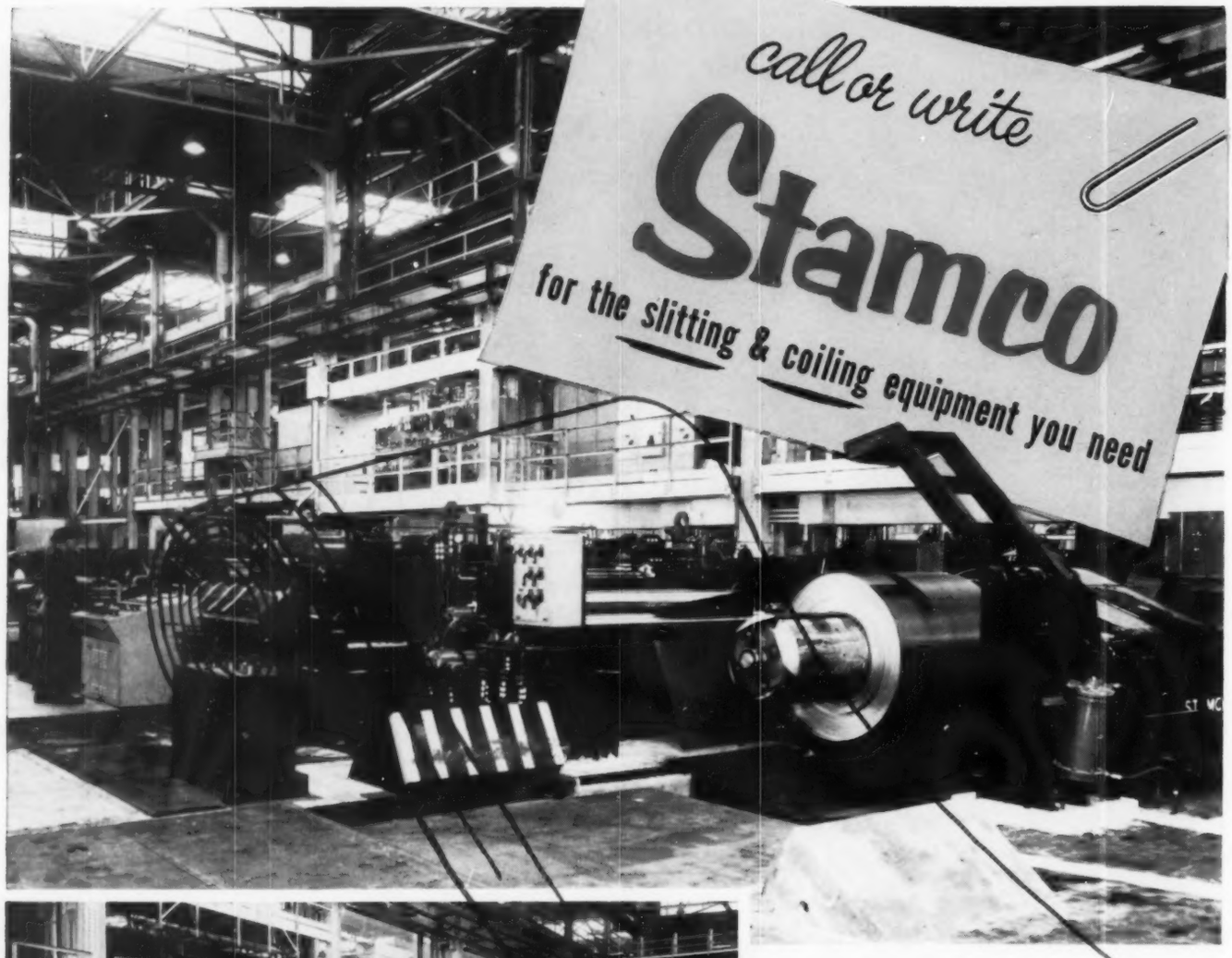
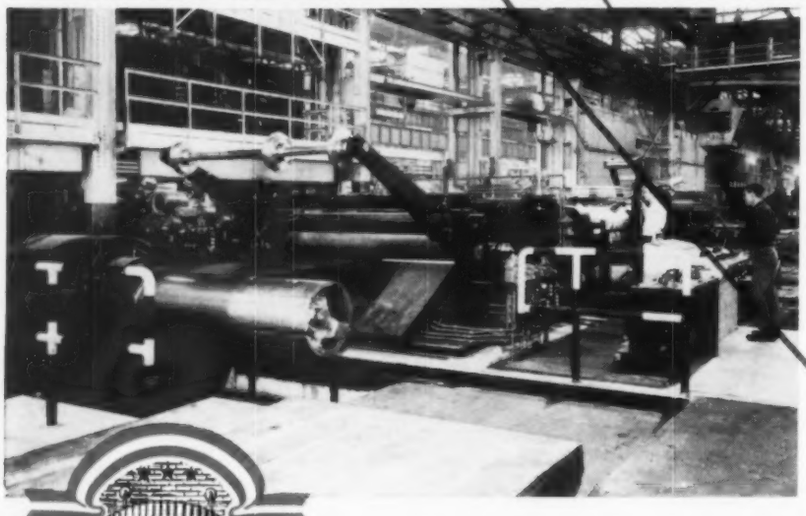
GPE

One of the largest slitting & coiling lines





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Slitting and Coiling Line

Years of experience have given us the ability to furnish equipment to meet every slitting and coiling requirement. Bulletin SC55 gives our complete story. Ask for it on your letterhead. No obligation.

Photos show Stamco slitting and coiling unit in cold strip mill

LAY YOUR SLITTING PROBLEMS AT STAMCO'S DOOR

STAMCO, Inc., New Bremen, Ohio

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JANUARY, 1958

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. . . any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

Note: Post cards expire three months after publication date.

(1) Low Voltage Switchgear

Major operating and maintenance innovations of its new K-line equipment are featured in a new bulletin published by I-T-E Circuit Breaker Co. The 20-page bulletin provides a complete review of the company's low-voltage power circuit breakers and switchboards, ranging in unit ratings from 225 to 4000 amperes. Advanced features of the new K-line breakers, whose ratings are 225, 600 and 1600 amperes, are described and illustrated in detail. Innovations include quick-make manual closure, pull-down handle actuation and simplification of trip unit continuous-current ratings. Construction advances, such as closed-door drawout, unitized assembly and increased accessibility of trip units, also are detailed. Application tables provide complete breaker ratings, control-power requirements and ranges of overcurrent trip devices.

Basic information on low-voltage power circuit breakers also is included in the new bulletin. A review of the three principal system types—fully rated, cascade and selective—aids in the selection of the proper breakers for low-voltage drawout switchgear applications. One bulletin section combines tables, data, a diagram and a graph to explain short-circuit currents in low-voltage systems. Another section includes dimensions, a sample specification form and a layout drawing of a typical switchgear assembly. The sample specification can be used as a guide for any switchgear installation (Bulletin 6004-C).

(2) Rotary Car Dumper

A new rotary car dumper, developed by Heyl & Patterson, Inc., is discussed in a catalog released by the company. Capable of handling hopper and gondola cars, the dumper is equipped with two clamps which hold the car secure without the use of counterweights. It can dump and return a spotted car in one minute with only 30 hp drive. Optional equipment consists of an electronic scale in the dumper platen which permits weighing and lightweighing car in the dumper and a power operated car retarder also on the dumper platen which permits rolling cars to be spotted without use of riders (Brochure 957).

(3) Silicone-Insulated Drives

Westinghouse Electric Corp. has published a booklet on its Life-Line "H" motors and generators, featuring silicone insulation. Illustrations and schematics depict many of the features of these d-c drives, including fast response, low maintenance, motor versatility, and motor flexibility.

(4) Open Hearth Equipment

Of interest to open hearth designers planning new facilities or modernization of existing shops, is a bulletin published by the Steel Plant Equipment Department of Blaw-Knox Co. Illustrations of water cooled doors, frames, reversing valves and dampers for open hearth construction are shown. In addition, labor and materials saving devices including the Dolomite Machine, Autopour and Ladles Additions Feeder are illustrated (Bulletin 2545-AJ57).

(5) Industrial Television

A brochure covering industrial TV for the metals industry, is available from Radio Corp. of America. It explains closed circuit TV and some of its applications, in addition to the television services offered by RCA.

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68	LEEDS AND NORTHRUP	DATA SHEET 643(1)	Thermocouples and speedomax recorder
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70	LINK-BELT CO.	BOOK 2550	Bearings
71	MARKAL CO.		Permanent markers
72	OKONITE CO., THE	BULLETINS IS-2117, IS-1088	Insulated wires and cables
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75	SPRAYING SYSTEMS CO.	CATALOG 24	Spray nozzles for hot strip spray cooling
76	TAYLOR INSTRUMENT COS.	BULLETIN 98261	Instruments and control systems
77	UNITED STATES GRAPHITE CO., THE	CATALOG B-56	Brushes
78	WAGNER ELECTRIC CORP.	BULLETINS MU-128 & MU-195	Motor-starter combinations
79	WATERBURY FARREL FOUNDRY & MACHINE CO.	CIRCULAR NO. 729-R	Tandem rod mills
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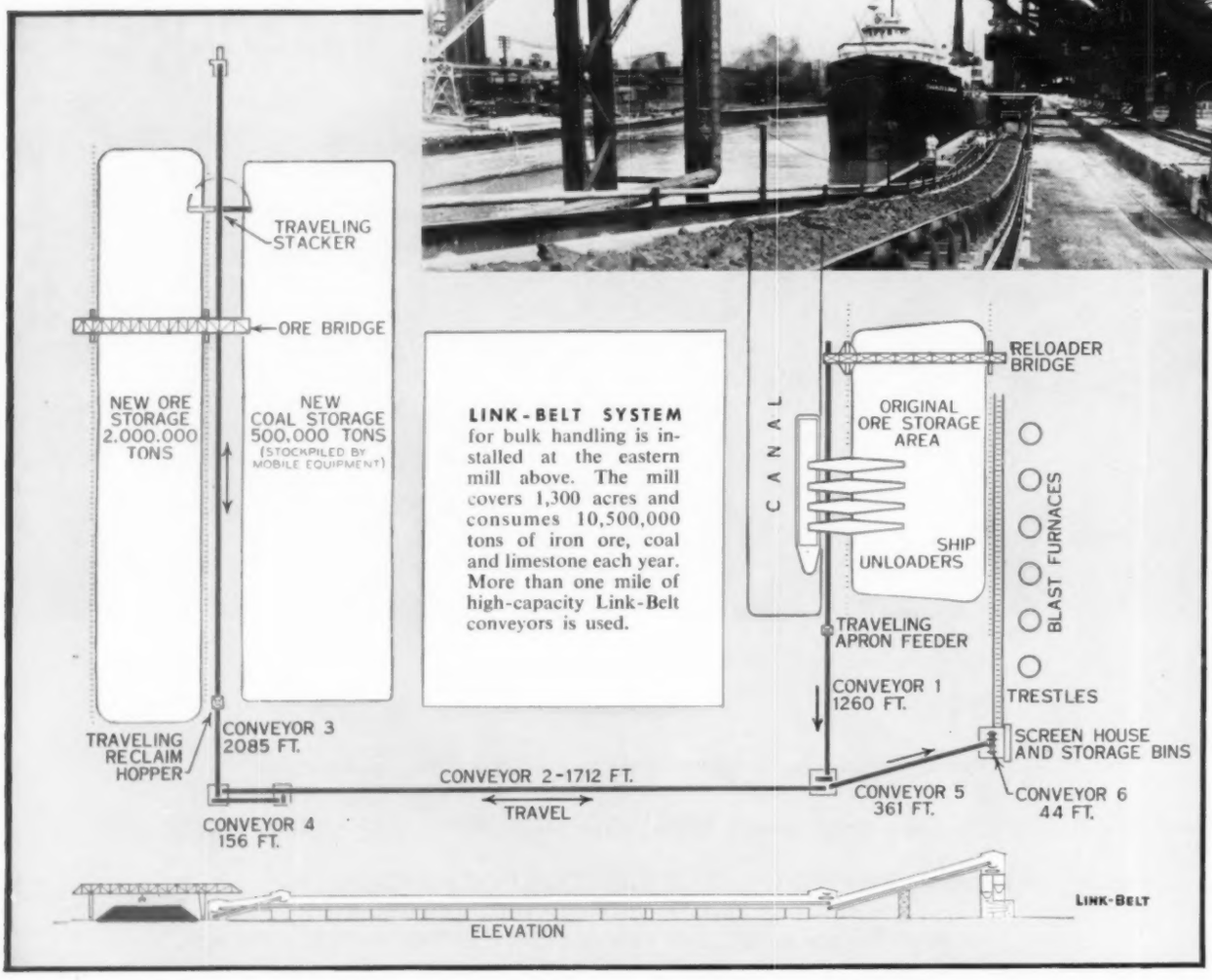
How LINK-BELT raw materials handling systems

keep pace with today's burdening techniques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LINK-BELT SYSTEM for bulk handling is installed at the eastern mill above. The mill covers 1,300 acres and consumes 10,500,000 tons of iron ore, coal and limestone each year. More than one mile of high-capacity Link-Belt conveyors is used.
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Personnel News...

Thomas W. Hunter was named general superintendent of Gary Steel Works of U. S. Steel Corp. He succeeds **John H. Vohr** who died December 1. Mr. Hunter goes to Gary from Pittsburgh where he has been assistant to vice president with duties concerned with the short and long range planning for all mining and manufacturing facilities of the corporation on a nationwide basis. He joined U. S. Steel in 1936 as assistant to the tin house superintendent of Shenango Works. In 1937, he transferred to Irvin Works as assistant to the superintendent of the tin finishing department and after several promotions was made superintendent of flat products at the plant in 1941. Mr. Hunter was transferred to Gary Sheet and Tin Mill, Gary, Ind., in 1944 and was tin mill division superintendent at the time of his return to Irvin Works as assistant general superintendent in October, 1950. He was made general superintendent of the plant in October, 1955, and assistant to vice president—operations on April 17, 1957.

Alex A. DeBlander has been appointed superintendent of the Jones & Laughlin Steel Corp.'s new stainless steel sheet and strip mill now under construction at Canton, Ohio. Mr. DeBlander has been associated with J&L's Stainless Steel Division since April of last year. Previously he served in various production management posts with Crucible Steel Co. and Universal-Cyclops Steel Co. His most recent position was with the stainless cold strip and sheet mill and the Silicon Division of Crucible at Midland, Pa.

C. A. Purbaugh has been appointed Duluth district manager of operations for U. S. Steel's American Steel & Wire Division. He succeeds **Harold Cope,** who retired after 47 years of U. S. Steel service. Mr. Purbaugh began his career with American Steel & Wire in 1935 as a clerk in the open hearth department at the Donora, Pa., Works. After advancing to foreman there, he was transferred to the Duluth plant as assistant works metallurgist in 1941. In 1945 he was made open hearth superintendent and in 1950 became general superintendent, the post he held when he was promoted to assistant district manager of operations last September.

Charles J. Petry was named assistant to the chairman of the board, Acme Steel Co. Mr. Petry comes to Acme Steel from Worcester, Mass., plant of the American Steel and Wire Division of U. S. Steel Corp. where he was division superintendent. He has been employed by U. S. Steel since 1939, and successively held the positions of department superintendent in the rolling mills, division metallurgist of hot rolling and assistant superintendent of the Worcester, Mass., works.

Alvin J. Scheel was promoted to the position of general superintendent of the Fairless Works of the National Tube Division, United States Steel Corp. Mr. Scheel succeeds **Thomas C. Beattie,** who recently retired after forty-two years of service with National Tube. Mr. Scheel joined the Fairless Tube Division in November, 1955, as assistant general superintendent from National Works, McKeesport, Pa. Mr. Scheel started his career with U. S. Steel in 1933, at National Tube's Lorain Works, Lorain, Ohio, in the wage payroll department. In 1937, he was promoted to foreman in the rolling mills and subsequently promoted to general foreman of the conditioning, finishing and shipping departments at Lorain Works. In 1947, Mr. Scheel was transferred to the National Works in McKeesport, Pa., as assistant superintendent, rolling mills, and was advanced to superintendent of that department in 1950. Four years later, he was appointed superintendent of the open hearth and Bessemer department—the position he occupied until his transfer to the Tube Division at Fairless Works.

Severn W. Kittredge was named assistant chief engineer of Sharon Steel Corp. He will transfer from the company's subsidiary Brainard Steel Division where he has been superintendent of the Larchmont plant.

John J. O'Connor has been promoted to manager, production planning, for the Stainless Steel Division of Jones & Laughlin Steel Corp. Mr. O'Connor, who was assistant manager of the department, succeeds **Wayne A. Lee,** who has resigned. He was employed by Rotary Electric Steel Co., which is now the Stainless Steel Division of J&L, in 1942 in a sales, customer service,

T. W. HUNTER

A. A. DeBLANDER

C. A. PURBAUGH

C. J. PETRY

H. F. McENTIRE

J. E. WORKMAN

E. P. SANDBACH

C. D. RAMSDEN

and pricing capacity. He was promoted to order manager for Rotary in 1953, and was named assistant manager, production planning, last year.

H. F. McEntire has been appointed chief engineer for Universal-Cyclops Steel Corp., Coshocton Works, Coshocton, Ohio. Mr. McEntire started his career with the Gulf States Steel Co., Gadsden, Ala., in 1922. Since then he has been associated with Aetna Standard Engineering Co., Great Lakes Steel Corp., Arthur G. McKee Co., The Yoder Co., Rotary Electric Steel Corp., United Engineering and Foundry Co. and Birdsboro Steel Foundry & Machine Co. He was chief engineer for Atlas Steels Limited, Welland, Ontario, from 1941 to 1957.

J. E. Workman has been appointed to the newly appointed position of executive vice president of Latrobe Steel Co. Mr. Workman joined the company in 1935 in a sales capacity in Toledo, and three years later was made district manager in Chicago. Seven years later he became acting sales manager and in 1947 was named vice president—sales. He is a member of the company's board of directors.

Edward P. Sandbach was named chief metallurgist for the Mackintosh-Hemphill Division of E. W. Bliss Co. He replaces **Charles E. Peterson,** who was recently named manager of manufacturing operations for the division's two plants. Previously, Mr. Sandbach was with United Engineering and Foundry Co.

C. D. Ramsden has been named president and general manager of the Pacific Coast Engineering Co., Alameda, Calif. The new President joined the firm in 1946 as chief engineer and served in that position until 1956 when he was appointed vice-president and general manager. He has been a director of the corporation since 1948. He has been associated with Copperweld Steel Co., Pittsburgh Coal Co., Western Knapp Engineering Co., and Copper Canyon Mining Co.

Henry G. Evans, general works manager of the Sharon Steel Corp., Roemer Works, Farrell, Pa., was appointed general manager of operations for the corporation. **William A. Horning,** assistant general manager of the Roemer works, becomes general works manager at that plant. Mr. Evans has been general works manager at Roemer since 1953. He joined the company in 1933 and has held various positions including foreman, plant metallurgist, blooming and bar mill superintendent. Mr. Horning has been his assistant since 1953 having joined Sharon in 1946 as plant superintendent of the Detroit Tube & Steel Division.

William R. Cook has been appointed wire mill superintendent of the Buffalo Plant of the Wickwire Spencer Steel Division, The Colorado Fuel & Iron Corp. Before joining CF&I, Mr. Cook had been associated with Union Wire Rope Corp. of Kansas City, Mo., as assistant wire mill superintendent.

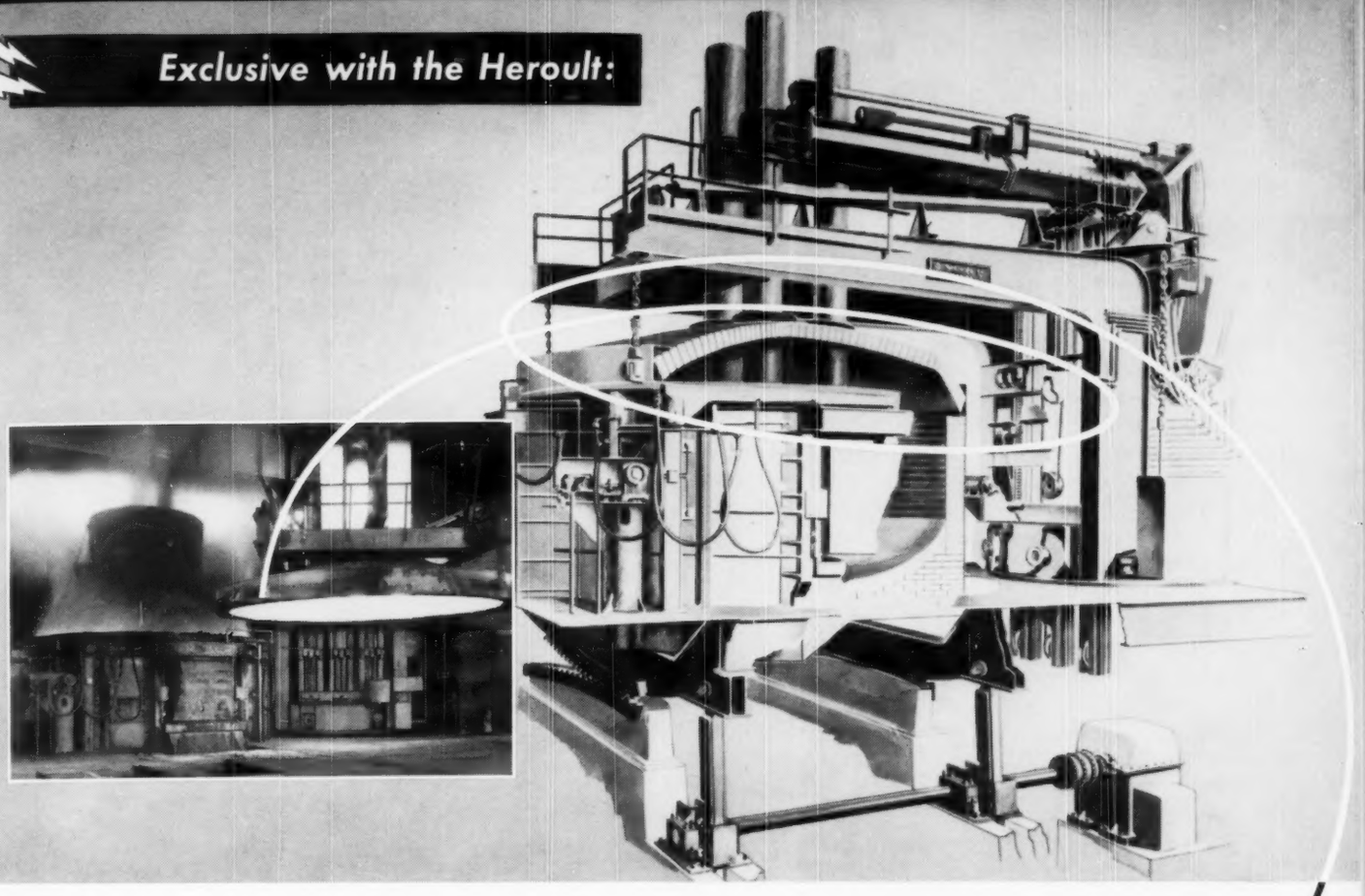
Harry R. Bohme has been appointed an assistant purchasing agent at Kaiser Steel Corp.'s Fontana plant. He served as superintendent of stores, in charge of the plant warehouses, since 1954. Mr. Bohme started with Kaiser Steel in 1949 with the General Sales Department in Oakland. That same year he became district order supervisor at the main office. He was next appointed assistant to the purchasing agent in Oakland and spent a year in Fontana in the same capacity. He was named senior buyer in the Purchasing Department at the plant in 1953 and then transferred to the Sunnyside Mines as purchasing agent. He returned to Fontana as superintendent of stores in 1954 and held that position for three years.

R. L. Puette and **B. H. Carlisle** have been appointed general divisional managers by The Clark Controller Co. Mr. Puette will continue as vice president—operations, of the company. His group will include the newly created Automation, Crane & Mill Accessory Controls,

R. L. PUETTE

B. H. CARLISLE

Exclusive with the Heroult:



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One of the features of the new Heroult is its low-cost maintenance. It is designed to make bricking easy and economical. Even the repair of the removable roof can be accomplished in much less time and with less labor and material cost. For the Heroult is the only electric furnace on the market with a water-cooled, skew-back type of roof ring. This patented design feature eliminates the need of special skew-shaped brick.

Embodying the latest in mechanical and electrical equipment, these widely used furnaces are noted for efficient performance and low operating and maintenance costs.

They are available in size of shell diameter ranging from 7′0″ up to 24′6″, and with rated charge capacity of from 8000 lbs. up to 400,000 lbs. They are equipped with removable roofs to permit top charging. Both gantry and swing-type roof-removing mechanisms are available. Door-charging furnaces and furnaces of special design, including units equipped with non-magnetic steel bottoms to permit induction stirring, can be supplied.

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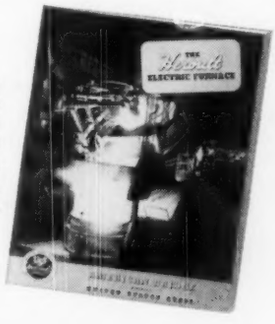

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United States Steel Export Company, New York

USS

UNITED STATES STEEL

and Packaged Speed Control & Control Centers Divisions. Mr. Carlisle's group will include the present American Electric Switch and Renewal Parts Divisions, as well as the new Standard Products Division.

Walter A. Schlegel has been assigned as resident chief metallurgist, Carpenter Steel of New England, Inc. **Elmer Schwartz** has been appointed general superintendent of the production departments. **James MacMinn** was named superintendent of billet preparation, and **Joseph J. Barrett** becomes assistant superintendent of hot rolling. Mr. Schlegel has been with the Carpenter metallurgical department since 1927. In 1954 he was advanced in the department to the position of metallurgist—tool and alloy steels. Mr. Schwartz has been active in the steel industry since 1919. In 1940 he became manager of the Youngstown District, Republic Steel Corp., and in 1946 he became president and general manager of Portsmouth Steel Corp. Later he returned to Republic Steel and advanced to assistant vice president. Prior to his association with the former Northeastern Steel Corp., in Bridgeport, Conn., he was vice president of Great Lakes Steel Corp., Detroit. He was with Northeastern since its inception in 1954.

Mr. MacMinn started his career with Carpenter as a metallurgical assistant in 1941. In 1945 he became plant metallurgist in the hot mills.

Mr. Barrett joined Carpenter in 1950. He became general foreman in the hot mills in 1951, and general foreman of the company's largest hot rolling mill in 1954.

John C. Borden, Cutler-Hammer vice president and controller, has been elected to the firm's board of directors. Mr. Borden joined Cutler-Hammer in 1929. He was appointed manager of renewal parts sales in 1935, and in 1944 was appointed manager of contract terminations. In 1947 he was named controller, and in November, 1955, he was elected vice president and controller.

Robert P. Stuntz has been appointed assistant sales manager of The Babcock & Wilcox Co.'s refractories division. Mr. Stuntz will make his headquarters at the company's executive offices in New York. Succeeding Mr. Stuntz as manager of the division's Chicago district sales office is **Robert H. Forsyth.**

Arthur W. Maas is the newly appointed manager of industrial product sales, R&IE Equipment Division, I-T-E Circuit Breaker Co., at Greensburg, Pa. He replaces **Howard Graybill,** who has been transferred to the capacity of manager of utility sales. Prior to his appointment, Mr. Maas was the San Francisco branch manager of Wagner Electric Corp. since 1950.

C. Richard Bayman was named sales engineer of the Herr Equipment Corp. Mr. Bayman, who will work out of the company's home office in Warren, Ohio, was formerly chief plant engineer of the Brainard Steel Division of Sharon Steel Corp.

Raymond T. Hegeman has been appointed sales manager of Refractory & Insulation Corp. Mr. Hegeman was formerly assistant sales manager, a position he held for two years.

James I. Ashley has been appointed sales engineer for the Press Division of the E. W. Bliss Co. Mr. Ashley was sales manager for Kenco Manufacturing Co., Los Angeles, before joining Bliss. In his new position, he will cover the southern California territory formerly served by **M. F. Strauss,** who has retired.

J. R. Walker, Jr., and **Ernest L. Ilsley** have been elected vice presidents of Kaiser Steel Corp. Mr. Walker formerly controller and assistant secretary, is elevated to the post of vice president and controller. Mr. Ilsley, in assuming his vice presidency, will continue as general manager of Kaiser Steel's Fabricating Division plants at Napa and Fontana, Calif.

Archie J. Smith was appointed Lake Erie Machinery Corp.'s new west coast representative. His offices will be located in Van Nuys, Calif.

George Gallousis was appointed as patents and standards engineer, Allis-Chalmers Pittsburgh Works. He succeeds **William H. Mutschler,** recently named chief engineer at Pittsburgh Works. Mr. Gallousis has been with Allis-Chalmers for 10 years. He had been an engineer in the instrument transformer section at Pittsburgh Works.

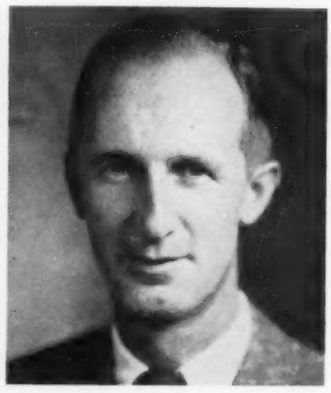
Stephen W. Benedict has been elected president of The Master Builders Co., Division of American-Marietta Co., and vice chairman of the board of directors of Master Builders Co., Ltd., of Canada. Other advancements were: **William B. Phillips,** promoted to executive vice president: **Robert G. Ahrens** to vice president and comptroller, and **Lane Knight** to

R. P. STUNTZ

A. W. MAAS

C. R. BAYMAN

R. T. HEGEMAN



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Sturdily constructed to withstand hard usage and abuse, their small cross-section permits comfortable, non-fatiguing, one-hand operation. Steel shrouds guard the large operating buttons. The heavy, all-welded steel frame (that includes the end-caps and front) has a heavy, fiber-glass, easily-removed rear cover that affords quick inspection of the silver-to-silver contacts without disturbing any wiring. The threaded conduit fitting is an integral part of the top end-cap which also has welded to it a double-suspension cable hanger.

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THE EUCLID ELECTRIC AND MFG. CO., MADISON, O. — EUCLID

president of The Master Builders Co., Ltd., Canada, subsidiary of American-Marietta Co. **Edward L. McFalls,** after 35 years with the company, is retiring as president, but will remain as marketing consultant.

J. F. Roberts, director of engineering, Allis-Chalmers Industries Group, and a vice president of the company, has retired. **R. C. Allen,** director of mechanical engineering, will report directly to the vice president in charge of the Industries Group. **W. M. Terry, Jr.,** chief engineer at Allis-Chalmers Pittsburgh Works, has been named to the new position of director of engineering co-ordination. Mr. Roberts started with Allis-Chalmers in the graduate training course in 1919. He was employed continuously from that time in the hydraulic department as a test engineer and later as a sales engineer until 1927 when he left to become hydraulic engineer for the Power Corp. of Canada. From 1936 to 1942, he was head hydraulic engineer for the Tennessee Valley Authority. In 1942 he returned to Allis-Chalmers to become manager of the hydraulic department. He was appointed director of engineering in May, 1951, and in September of the same year, vice president and director of engineering Industries Group.

Mr. Allen joined the steam turbine department of Allis-Chalmers in 1936. He served successively as chief engineer, assistant manager, and manager and chief engineer of the steam turbine department until 1947 when he became manager and chief engineer of the turbo-power development department. Prior to his appointment to his present position in May, 1954, he was consulting engineer in the office of the director of engineering for three years.

Mr. Terry joined Allis-Chalmers in 1947 as a development engineer. In 1952 he was named assistant chief engineer at Pittsburgh Works and in 1956 he became chief engineer.

Paul H. Daley was promoted to director of sales and **J. O. Phillips** to assistant manager, forging and die steel sales, of Heppenstall Co. Mr. Daley joined the company in 1946 as an industrial engineer at the Bridgeport, Conn., plant. Transferred to Pittsburgh in 1948, he became general superintendent in 1950, assistant general manager of operations in 1953, and general manager of operations in 1955. Mr. Phillips started with the company in 1942, at a plant then

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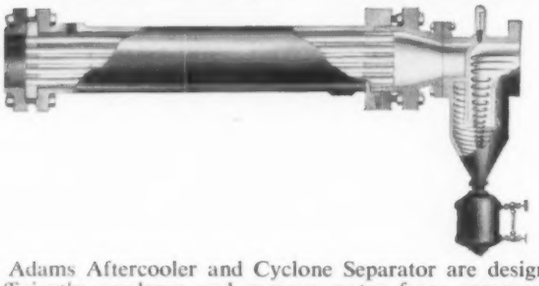

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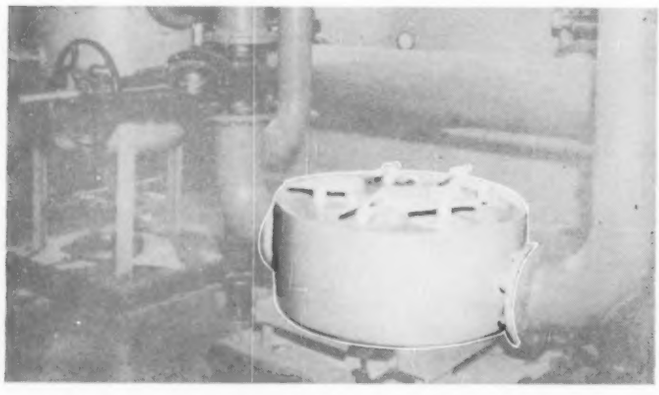

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operated for the Navy at Eddystone, Pa. He was transferred to the Detroit sales office in 1948 and to the Pittsburgh sales department in 1949. He became assistant to the general manager of sales in 1952 and has served as assistant to the president since 1956.

W. J. Smetak was elected president, treasurer and general manager of the Wm. K. Stamets Co. and its subsidiary, the Stamets Export Co. **Henry R. Hanson** has been elected vice president and general manager of the distributor division, and **A. H. Long,** formerly chief engineer, has been elected vice president of engineering. **Wm. K. Stamets, Jr.,** was elected president and general manager of the Enterprise Co. He was formerly chief engineer and sales manager of Enterprise. He will also continue as vice president of the Wm. K. Stamets Co., and the Stamets Export Co.

J. W. Luoma has been appointed technical assistant, Chicago Office, of the roll sales department of Blaw-Knox Co. In his new position, Mr. Luoma will establish specifications for rolls and assist roll salesmen on quality and technical matters. He joined a predecessor component of the company in 1929. He became roll foundry superintendent, and in 1953 was made manager of metallurgy in the foundries of Continental Foundry & Machine, now part of Blaw-Knox.

William H. Mutschler has been appointed chief engineer of Allis-Chalmers Pittsburgh Works. Formerly patents and standards engineer at Pittsburgh Works, Mr. Mutschler succeeds **W. M. Terry, Jr.,** who was recently named director of engineering coordination for the company's Industries Group.

N. W. Richardson has joined Heat and Control, Inc., at San Francisco, Calif. He will be manager of mill process heat application, and will also support Los Angeles and Seattle office activity in that field. Mr. Richardson was formerly associated with Colorado Fuel and Iron Corp., National Tube Division, U. S. Steel Corp., and Salem Engineering Co. Prior to joining Heat and Control, Inc., he was with American Industrial Furnace Co.

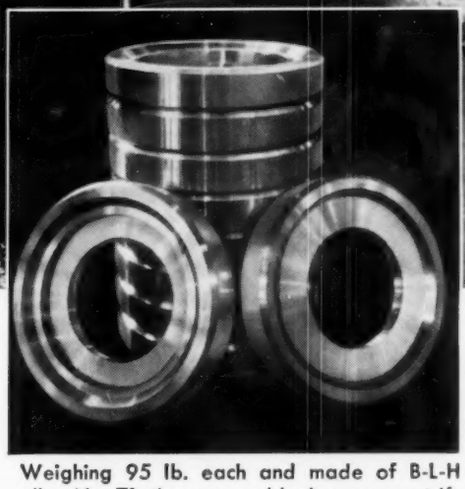
Alfred Augustine has been named director of engineering, Loftus Engineering Corp. At the same time **Edward A. Siemon** was appointed chief engineer, and **C. R. Wilt, Jr.,** assistant chief engineer.

William H. Oler has been appointed sales manager, Engineering Division of Hauck Manufacturing Co. He was formerly regional sales manager for western Pennsylvania, Ohio and Michigan.

Obituaries

F. H. Moyer, 81, who retired as consulting engineer for Copperweld Steel Co. in 1952, died November 18. Mr. Moyer began his career in the steel industry with Carnegie Steel Co. in Pittsburgh. He served as chief engineer, successively at Clairton works, Illinois Steel Co., and Cambria Steel Co. He served as assistant manager of Crucible Steel Co. and vice president in charge of engineering, United Alloy Steel Co., and president of Mackintosh-Hemphill Co. Prior to joining Copperweld he served as chief engineer of National Tube Co.

At Eddystone two hot strip mill slippers cast of B-L-H alloy No. 83 are machined on a vertical boring mill.



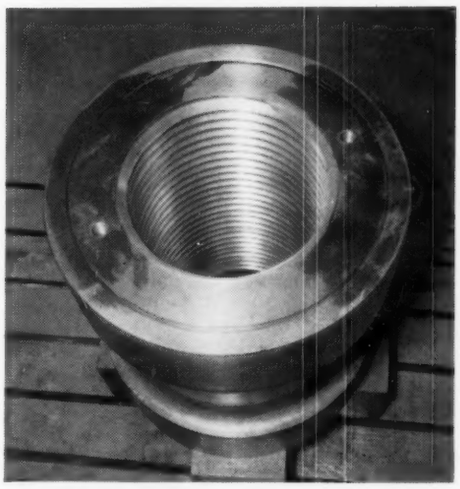
Weighing 95 lb. each and made of B-L-H alloy No. 71, these gear blanks were centrifugally cast and machined at Eddystone.

4 reasons for specifying finish-machined castings by Baldwin

It will pay you to let Baldwin finish machine as well as cast your slippers, gear blanks, and housing nuts. Here's why:

1. Since finish-machined castings are so much lighter than rough castings, your shipping expenses are substantially lower
2. By having the entire operation handled in one shop you save time and place the complete responsibility on one source
3. You eliminate the possibility of receiving defective castings, for any flaws would be uncovered in the machining operation
4. You take full advantage of Baldwin's unexcelled shop facilities, which include spectroscope, electron microscope and X-ray machines, for both research and quality control

For complete finish-machined slippers, gear blanks, housing nuts, or other bronze parts, always look to Baldwin. Write for our illustrated Foundry Bulletin 6002.



Screwdown unit housing nut cast and finish machined at B-L-H's Eddystone Division.

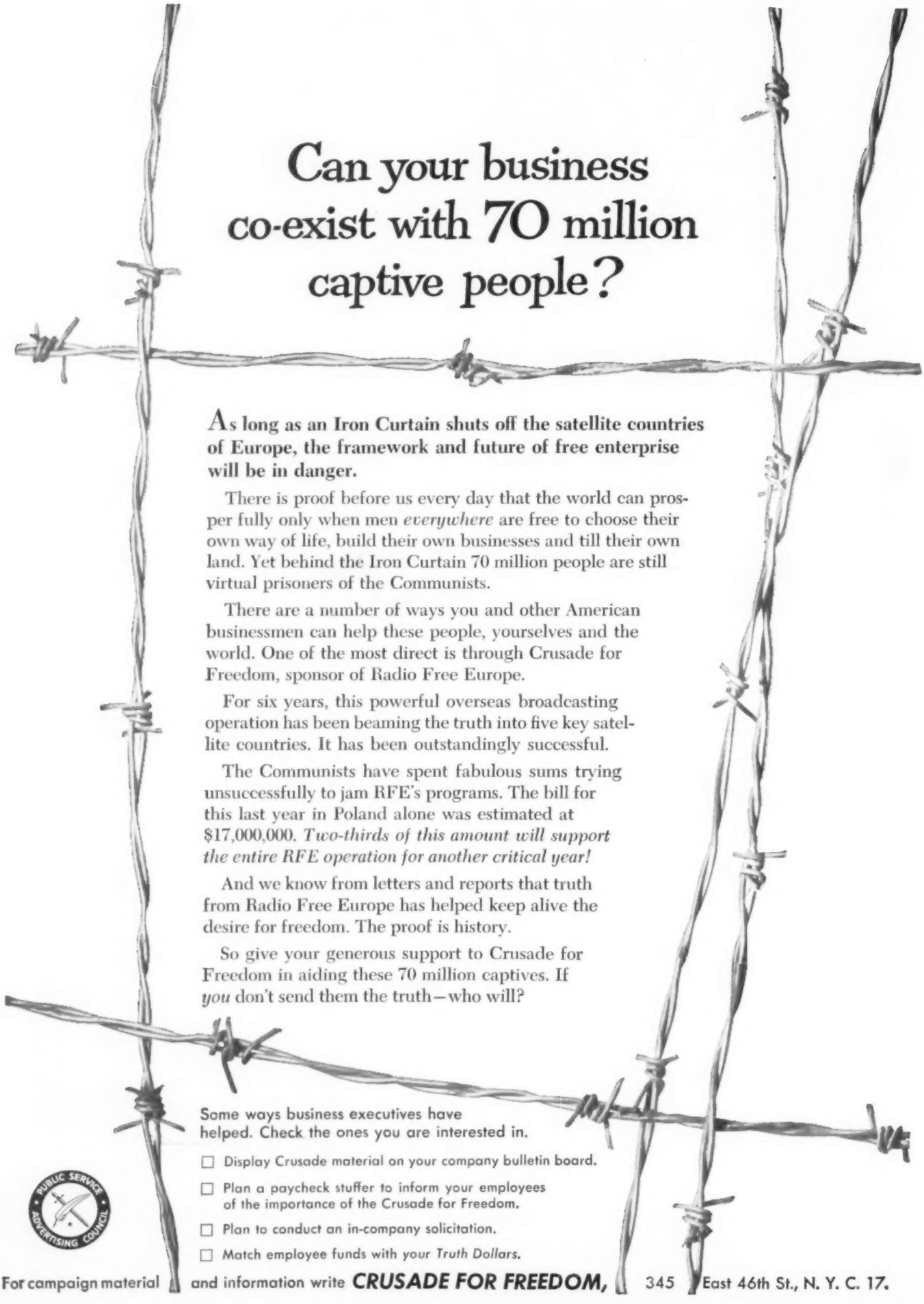
BALDWIN · LIMA · HAMILTON

Eddystone Division

Philadelphia 42, Pa.

Hydraulic turbines • Weldments • Dump cars • Nonferrous castings • Special machinery • Bending rolls • Machine tools

Can your business co-exist with 70 million captive people?



As long as an Iron Curtain shuts off the satellite countries of Europe, the framework and future of free enterprise will be in danger.

There is proof before us every day that the world can prosper fully only when men *everywhere* are free to choose their own way of life, build their own businesses and till their own land. Yet behind the Iron Curtain 70 million people are still virtual prisoners of the Communists.

There are a number of ways you and other American businessmen can help these people, yourselves and the world. One of the most direct is through Crusade for Freedom, sponsor of Radio Free Europe.

For six years, this powerful overseas broadcasting operation has been beaming the truth into five key satellite countries. It has been outstandingly successful.

The Communists have spent fabulous sums trying unsuccessfully to jam RFE's programs. The bill for this last year in Poland alone was estimated at $17,000,000. *Two-thirds of this amount will support the entire RFE operation for another critical year!*

And we know from letters and reports that truth from Radio Free Europe has helped keep alive the desire for freedom. The proof is history.

So give your generous support to Crusade for Freedom in aiding these 70 million captives. If *you* don't send them the truth—who will?

Some ways business executives have helped. Check the ones you are interested in.

- ☐ Display Crusade material on your company bulletin board.
- ☐ Plan a paycheck stuffer to inform your employees of the importance of the Crusade for Freedom.
- ☐ Plan to conduct an in-company solicitation.
- ☐ Match employee funds with *your Truth Dollars.*

PUBLIC SERVICE ADVERTISING COUNCIL

For campaign material and information write **CRUSADE FOR FREEDOM,** 345 East 46th St., N. Y. C. 17.

Any similarity to a real-life company is purely intentional

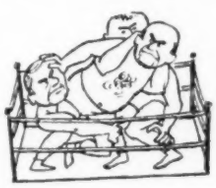
How does the master mechanic avoid tons of trouble?

When Flint N. Steele got his first job, he was determined to set the world afire. He had lots of spark — went on to big things. Today, he's one of the mighty over at Mighty Metals — master mechanic, to be exact.

MM rolls heavy tonnage in the course of a year. You never catch *them* with their plants down! And you never will, if Flint Steele has his way.

"No peanut-brittle part failure is going to foul up our production schedules!" is the way he puts it. Or words to that effect.

Now if you've ever seen a high-speed, continuous rolling mill, you know that it develops more impact, leverage, and load than a ringful of wrestlers. Several million instantaneous inch-pounds is nothing! (That's nothing?) Guarding against costly downtime is a mighty weighty problem indeed.



One way that Flint does it is by insisting on Ampco Metal at all critical points; for instance: (1) in the screw-down nuts; (2) in the screw-down worm wheel; (3) in the slippers (universal-joint bearing segments); (4) in the breaker blocks.

Ampco Metal is a uniform-quality copper-base alloy of such special yet sound structure that it withstands severe pressures and shock—and the abrasive action of powdered scale. It resists corrosion, so avoids the extra expense of special lubrication.

These characteristics make Ampco Metal especially suitable for use also in wearplates, pickling operations, and other production applications.

Where can Ampco save money for *you?* Talk it over with your nearby Ampco field engineer. And write for Bulletin 33 today. *Ampco Metal, Inc., Dept. IS-1, Milwaukee 46, Wisconsin (West Coast Plant: Burbank, Calif.)*

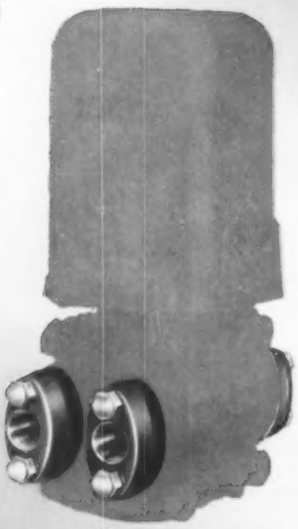
AMPCO® METAL

The metal without an equal

G-3

FOXBORO d/p CELL

unequaled –



Simplest installation — orifice flange tap connections at standard spacing, are provided at both ends.

Drain and vent holes at lowest and highest points on both sides.

Purged cover protects transmitter from weather, dust, and fumes.

Over 60,000 now in use!

No zero drift . . . positive overrange protection . . . high sustained accuracy even under the most punishing operating conditions. No wonder over 60,000 Foxboro d/p Cell Transmitters have been installed since they were introduced in 1948.

By introducing the modern concept of high speed flow measurement and control, these differential pressure transmitters have *revolutionized* many an industrial process. Bulletin 13-11A shows how — and portrays the benefits the d/p Cell Transmitter offers you. Write **The Foxboro Company, 581 Neponset Ave., Foxboro, Mass., U.S.A.**

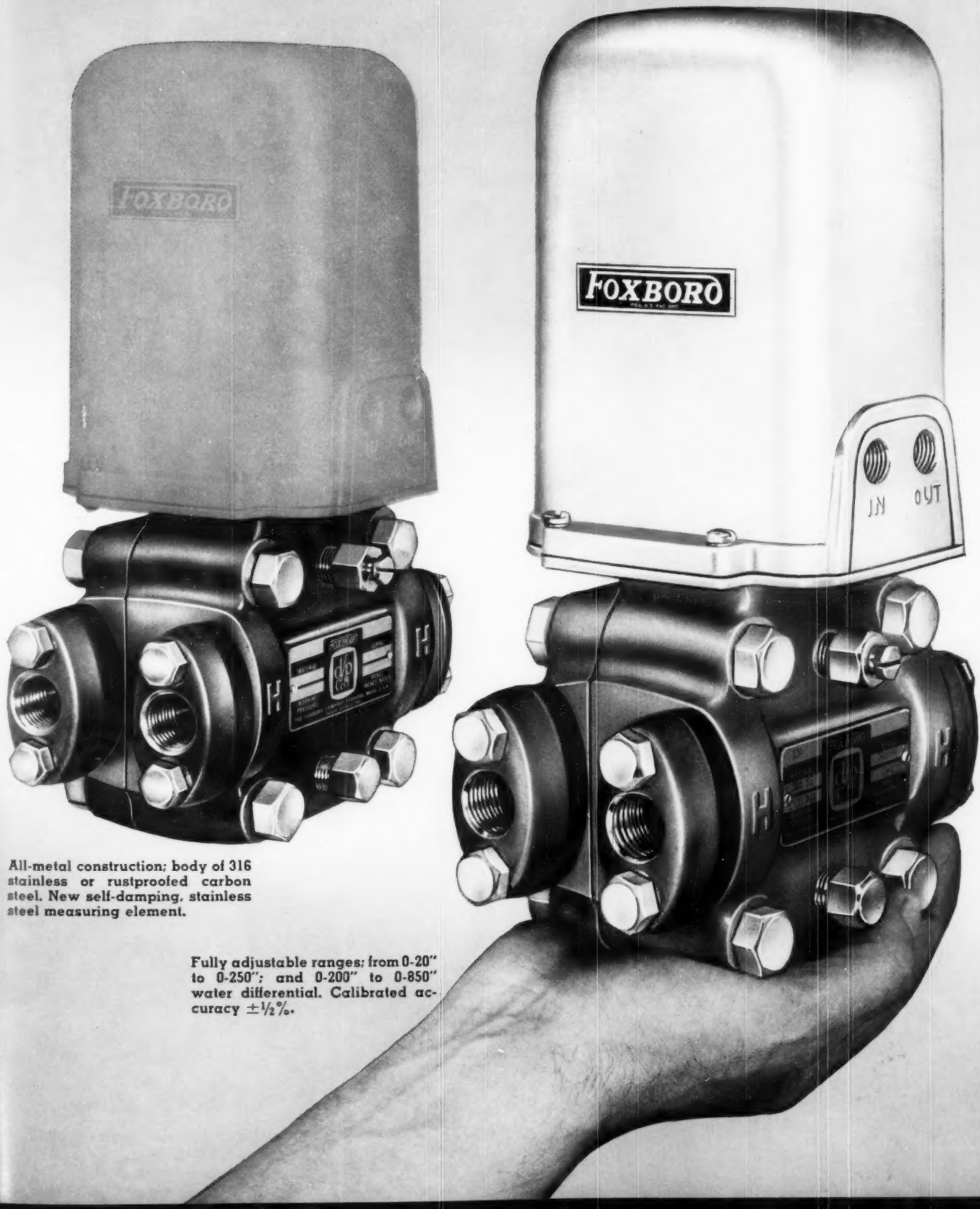
FOXBORO

REG. U.S. PAT. OFF.

FIRST in Flow Measurement and Control

FLOW TRANSMITTERS...

in accuracy, stability and performance



All-metal construction; body of 316 stainless or rustproofed carbon steel. New self-damping, stainless steel measuring element.

Fully adjustable ranges: from 0-20" to 0-250"; and 0-200" to 0-850" water differential. Calibrated accuracy ±½%.

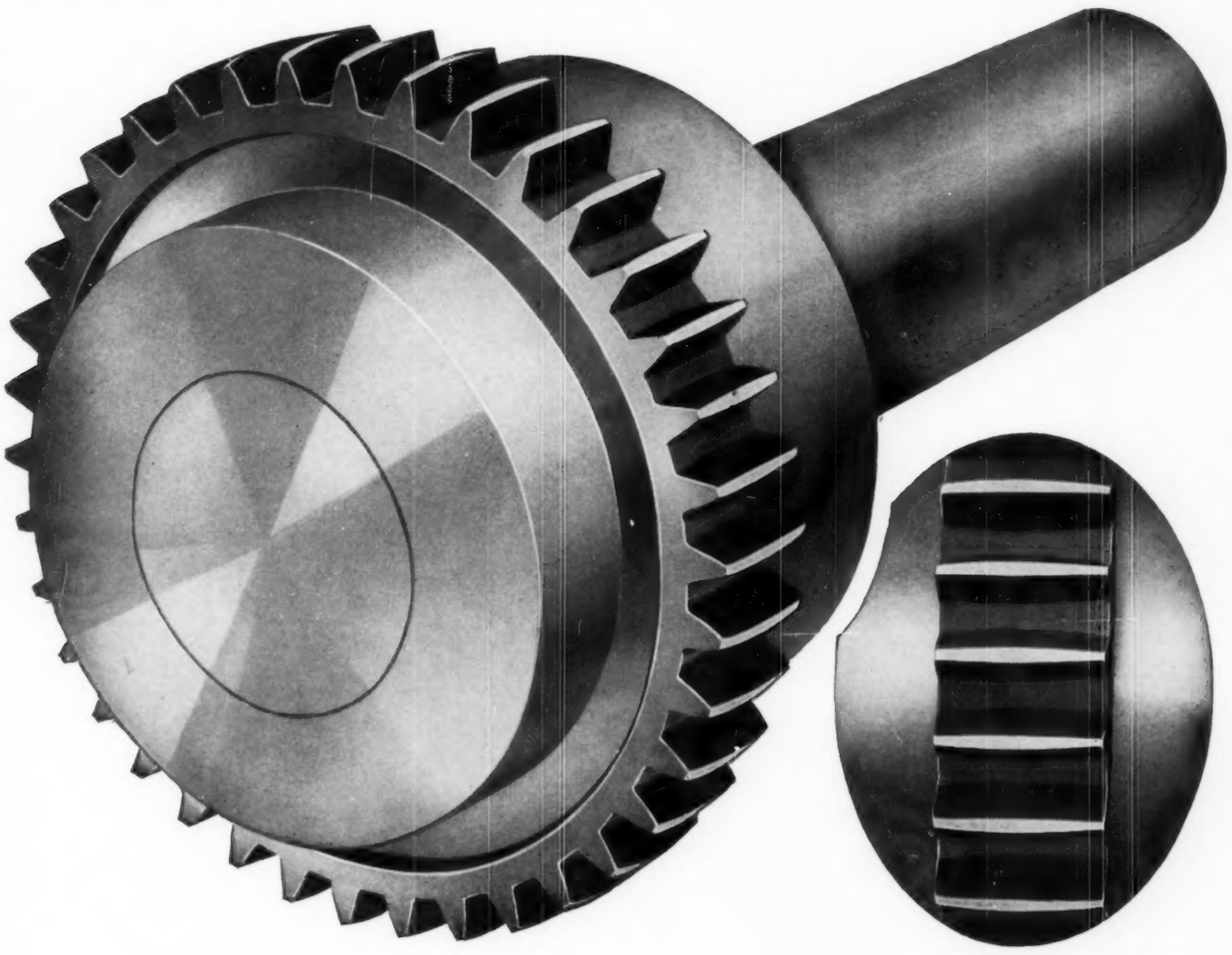
TAKING
STOCK
IS GOOD
BUSINESS
If you're in business, you take inventory at least once a year. It's essential to the health of your business to know where you stand. But have you taken stock of yourself recently? Do you know where you stand when it comes to cancer?
A once-a-year health checkup can tell you.
The chances of curing cancer are far greater when it is detected early and treated promptly. Living proof are the 800,000 Americans who *have been cured.*
Yet lung cancer now kills 24,000 men annually...eight times as many as twenty years ago. And thousands of these deaths could have been prevented *if the cancer had been diagnosed early and treated promptly.*
That's why it's vital for every man to have a health checkup every year, including a chest x-ray. Further, if a cough or hoarseness lingers for more than two weeks – one of cancer's danger signals – an immediate visit to the doctor is indicated.
Give yourself the same break you give your business. Take that personal inventory regularly – have a health checkup every year.
AMERICAN CANCER SOCIETY

POOLE

CURVED TOOTH COUPLINGS FOR GREATER MISALIGNMENT

We are now equipped to furnish on special order, couplings up to and including size No. 12 with curve-sided hub teeth, permitting misalignment up to plus or minus 5°.

This feature solves many problems where excessive misalignment becomes unavoidable, such as coupling arrangements which necessitate changing centers of rolls etc., or any sort of drive requiring more than the standard plus or minus 1°.



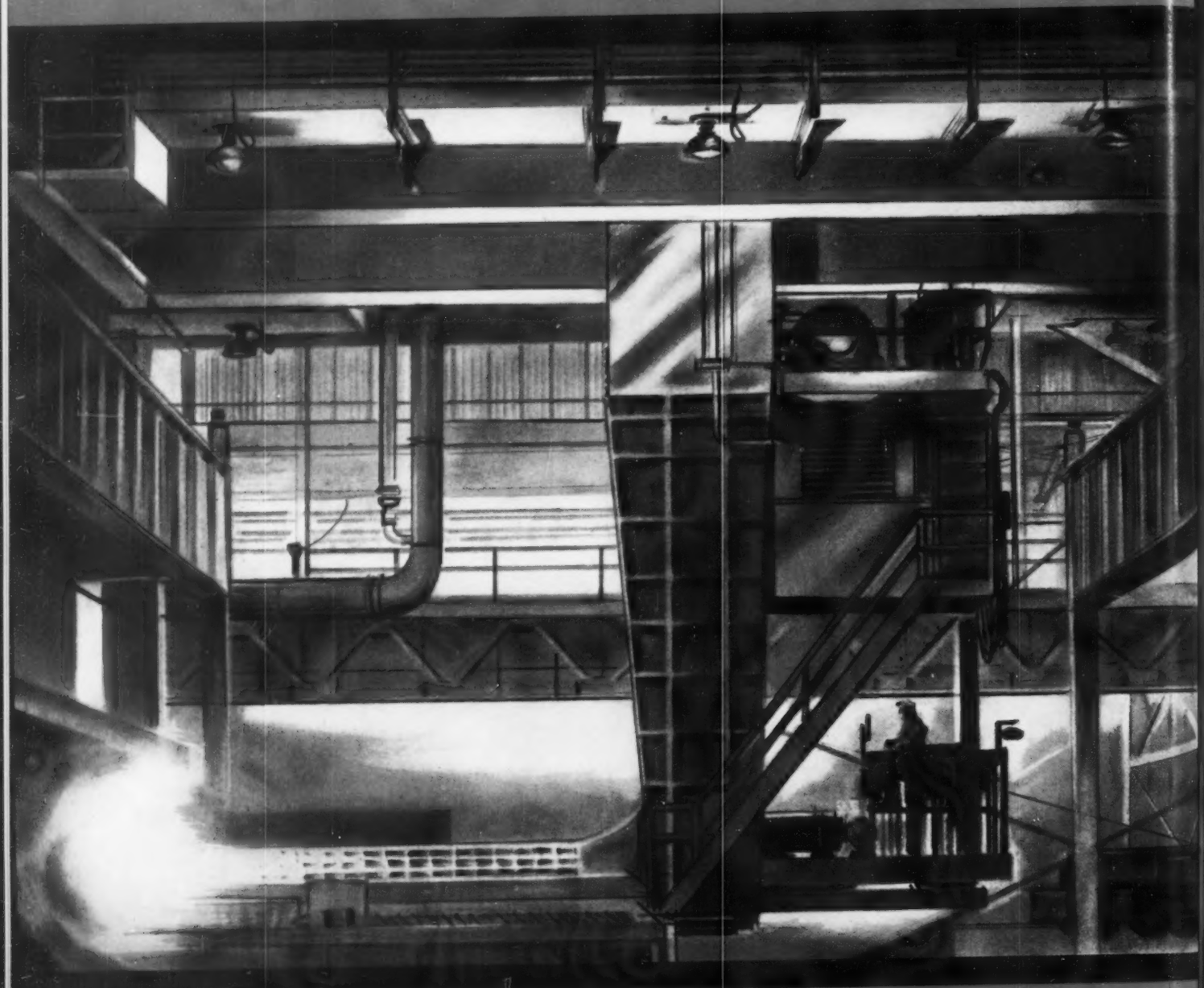
The method by which this is done represents the very latest gear cutting process. Gear teeth cut by this amazing and ultra modern method are not only to a precise and absolutely true shape, but are also generated to tolerances of astounding accuracy.

Engineers and draftsmen, when confronted with coupling problems involving more than the usual amount of misalignment, are invited to submit such problems to us for recommendation to suit their exact requirements.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY **1700 UNION AVE.** **BALTIMORE 11, MD.**

CRANE-TYPE SLAB CHARGING MACHINE



This 20-ton crane-type slab charging machine is equipped with end grip tongs. There are no tracks on the floor to hinder movement of wheeled equipment. The peel and mast are arranged for 360° rotation. Peel raises and lowers in horizontal position at all times. The operator's position, with reference to the peel and slabs he is handling, is fixed. His vision is unobstructed. This is one of many safety-engineered Alliance heavy-duty handling devices. For practical, economical solutions to your materials handling problems consult the Alliance engineers. They'll work with you to create the one device that meets your needs best.

Alliance

"Give us the Runway and we'll lift the World"

THE ALLIANCE MACHINE COMPANY • MAIN OFFICE • ALLIANCE, OHIO

LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS • SOAKING PIT CRANES • STRIPPER CRANES • SLAB AND BILLET CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION • COKE PUSHERS

Equipment News...

SYNCHRONOUS CONDENSER

Δ A 30,000-kva Allis-Chalmers hydrogen-cooled synchronous condenser successfully stabilizes voltage conditions in an arc furnace in a southern steel plant.

Low reactance synchronous condensers are frequently operated in parallel with arc furnaces to reduce voltage fluctuations. An unusually low transient reactance—20.6 per cent as compared with a normal 30 per cent—makes this condenser particularly well suited for this application.

Construction features of this 13,800-volt, 3600-rpm, 3-phase, 60-cycle machine are unique for synchronous condensers. Both stator and rotor coils are cooled by hydrogen gas flowing at high velocity in direct contact with conductor copper. This cooling system is so effective that a significant reduction has been made possible in the physical size of the unit.

A 700-hp, 2300-volt, 1740-rpm wound rotor induction motor is used in this installation for starting the machine. It is geared to the condenser along with a 175-kw, 135-volt, 1750-rpm d-c exciter.

GEAR REDUCER

Δ A shaft mounted gear reducer that eliminates need for motor bases, rails, supporting structures and flexible couplings is now available from Lovejoy Flexible coupling Co. It provides a compact, space-saving power transmission unit for countless industrial applications. The reducer also eliminates alignment problems and makes possible infinite speed ratios through the use of variable speed pulleys or by changing sheaves, sprockets or prime mover speed. Proper belt tension between drive and driven unit is maintained by simple adjustment of the rod and turnbuckle.

Eighteen models, including single and double reduction types, can be supplied from stock. Single reduction types are 98 per cent efficient and afford 4.5:1 speed ratio (nominal). Double reduction types are 96 per cent efficient and afford 14.7:1 speed ratio (nominal). Horsepowers range from fractional to 120, output speeds from 8 to 425 rpm.

The reducer is easily installed direct to driven shaft and can be mounted vertically or at any angle. Hollow shaft bores range from $1\frac{7}{16}$ in. to $5\frac{15}{16}$ in., with bushings available to accommodate slightly undersize driven shafts. Slightly oversize driven shafts can be necked down or can be accommodated in the same manner as undersize by using a larger reducer.

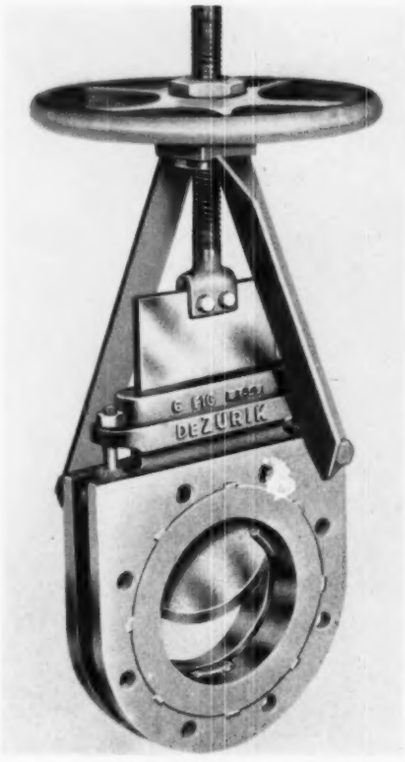
For applications such as inclined conveyors, horizontal mixing drums, etc., where protection against reversal of direction is required, a roller backstop can be furnished. This guarantees complete safety, since the backstop allows only one way movement of the driven shaft—regardless of whether power is on or off. Simply installed by removing three screws and a plate on the housing opposite the input shaft, it is inserted over the input shaft and inside the gearcase. Thus, the reducer's dimensions are not altered in any way.

Torque reaction brackets can also be furnished for units with platform-mounted or reversing drives.

GATE VALVE

Δ A new fabricated bonnetless gate valve, designed for handling fibrous, viscous and slurry type flows has been announced by the DeZurik Corp.

The valve has a round port bottom, eliminating square "corner cavities" or pockets where solid material can pack and interfere with full descent of the gate, preventing shut off. The lower end of the gate is sharpened to shear its way through fibers or other solid material in the flow. The upper end is full width and extends through the packing gland, com-



pletely eliminating the bonnet cavity usually found on gate valves. The gate is made of heavy plate to prevent distortion and buckling under line pressure.

The usual construction consists of carbon steel flanges with a stainless steel facing ring on each flange extending out to the bolt circle. Heavy ribs join the flanges into one solid unit which will not distort and bind the gate when subjected to piping strains. The body chest, seat ring, gate and all other wetted parts are of stainless steel. With this type of construction the valve offers excellent corrosion resistance, yet is economically priced.

A large yoke head provides liberal bearing area for the operating nut. The stem, of 18-8 stainless steel, has double-pitch threads for fewer turns of the hand-wheel and less wear on operating parts. The external ni-resist metal stuffing box is corrosion resistant to both acid and alkaline services. Its inverted design is self-aligning with the gate; side pressure on the gate, usually occurring when a stuffing box with an internal gland is used, is completely eliminated. In

Profitable Trends in the use of Refractories

Photos courtesy of Atlantic Steel Company

New furnaces start right with Laclede-Christy Refractories

Specifications on Atlantic Steel Company's new 13″ Bar and Rod Mill included a 90 ton per hour reheating furnace. They called on a leader in the field, Rust Furnace Company, to build it. Rust's experience and knowledge prompted their use of Laclede-Christy refractories.

The installation included Spallac super-duty fire brick which has proved its long-lasting qualities in other installations . . . requiring minimum maintenance and reducing downtime. Spallac super-duty features high refractory value, good volume stability, and high resistance to spalling. Also included was Laclede King high duty brick.

To start your furnace right—for new or replacement installations, it pays to use Laclede refractories. Call Laclede-Christy Works, Refractories Division, H. K. Porter Company, Inc., St. Louis 10, Mo.

H. K. PORTER COMPANY, INC.
REFRACTORIES DIVISION

addition to contributing to easier operation and tighter shut off, the inverted design reduces the required number of stuffing box adjustments, considerably lowering maintenance costs.

The valves are available in sizes from 3 in. to 24 in. with handwheel, lever, cylinder and similar operators. A positioner can also be furnished on the valve for throttling control.

The model illustrated is a wafer pattern which has a face-to-face dimension only 2¼ in. on the 6 in. size, and 3¾ in. on the 24 in. size. Other models have standard gate valve face-to-face dimension as well as a short face-to-face, intermediate to the wafer and standard dimensions.

WALL MOUNTED SWITCH

△ A new metal enclosed load interrupter switch, Type HPC-W has been announced by the R&IE Equipment Division of I-T-E Circuit Breaker Co.

The switch is built for wall mounting where primary switching requires the safety of metal enclosures. The main switch blade is equipped with a quick-break blade with tungsten tips which extinguishes all arcing in a plastic arc chute. Stationary break contacts have special heavy spherical tips which protect the current carrying surfaces of the contact against possible high fault currents during closing operations.

Housings are 11 gage steel and are supplied with mechanical door

interlocks, and if required, Kirk Key Interlocks on the operating handle.

Cubicles are finished in synthetic baking enamel, dark gray for outdoor and light gray for indoor.

The switch can be supplied for either hook or direct manual operation. Ratings are 4.8, 7.2 and 13.8 kv, for 600 ampere service.

GAS GENERATORS

△ The A. A. Straub Co. Inc., has introduced a new line of Exothermic gas generators designed to produce inert gas efficiently by burning fuel gas under controlled conditions. Output capacities of the standard models range from 500 to 25,000 cfhr with larger models available to meet individual requirements.

The inert gas, produced by the generator is low in cost and is used in many industrial operations—typically, as a blanketing gas to prevent the formation of scale in such heat treating operations as sintering, bright furnace brazing, clean hardening and bright annealing.

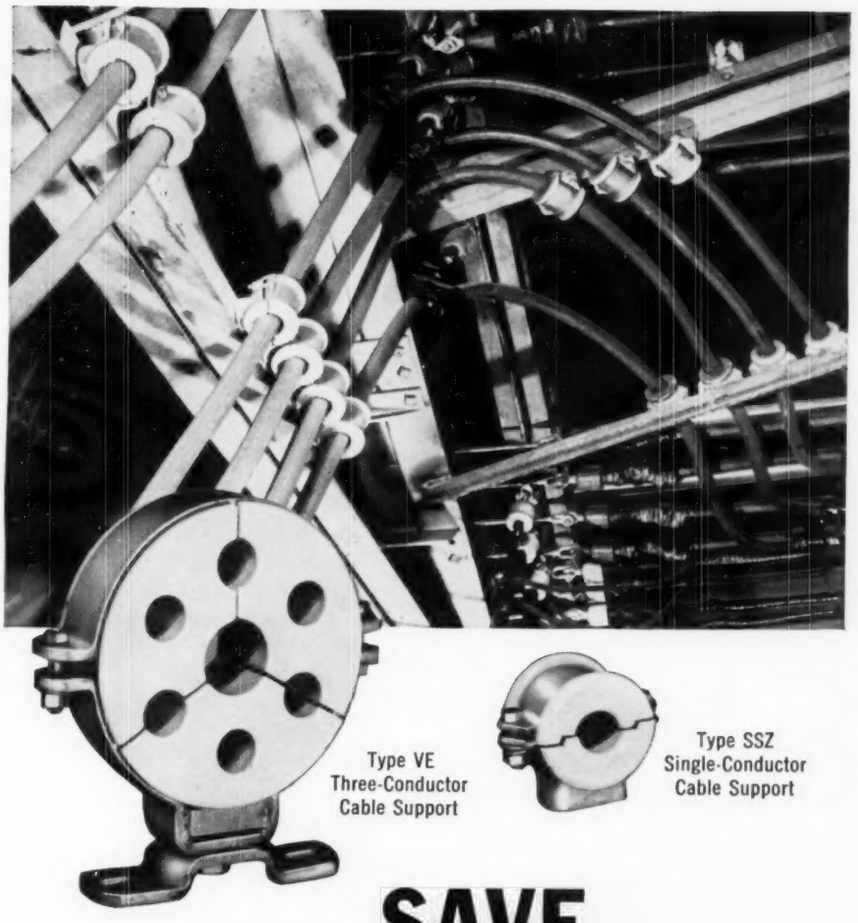
The units are designed as packaged units and are available for fast delivery and can be placed in operation with a minimum of time and effort. Their efficient layout permits installation in small floor space.

The generators make use of firebrick lined, water jacketed combustion chamber in which fuel gas is burned to produce a product gas of desired composition. When operating on natural gas the products of combustion have the following approximate composition.

These generators are completely automatic and require a minimum of maintenance or attention. They are equipped with all necessary safety and control devices to assure safe, accurate operation. Quality and volume of the product gas is controlled within extremely close limits.

They can be installed in any plant having fuel, water and electricity available in the following requirements based on the needs for each 1000 cfhr of capacity: Fuel, 110 cfhr based on 1000 Btu gas: Electric power, 1 kwhr/hour; Water 275 gphr at 30 psi and a minimum temperature of 75 F.

(*Please turn to page 255*)



SAVE TIME AND MATERIAL

with open wiring and Delta-Star clamp-type cable supports

You save space, reduce installation time and costs when you install this flexible, high-voltage system. Open wiring permits cables to be worked at higher current densities . . . taps, extensions, and rearrangements to be made easily.

Choose from two types of Delta-Star cable supports: Type VE and Type SSZ. Mount either type on pipes, beams, and other flat surfaces.

Type VE is a three-conductor cable support—all conductors in same clamp. Close triangular spacing balances circuit. Reduces voltage drops over long distance. Type SSZ is a single-conductor cable support with adaptor plates for group-mounting two, three, or four supports.

For detailed information, write for this new catalog, publication 4901. Address: DELTA-STAR ELECTRIC DIVISION, H. K. PORTER COMPANY, INC., 2437 FULTON STREET, CHICAGO 12, ILLINOIS. DISTRICT OFFICES IN PRINCIPAL CITIES.

H. K. PORTER COMPANY, INC.

DELTA-STAR ELECTRIC DIVISION

PRECISION-ENGINEERED

meets highly exacting standards

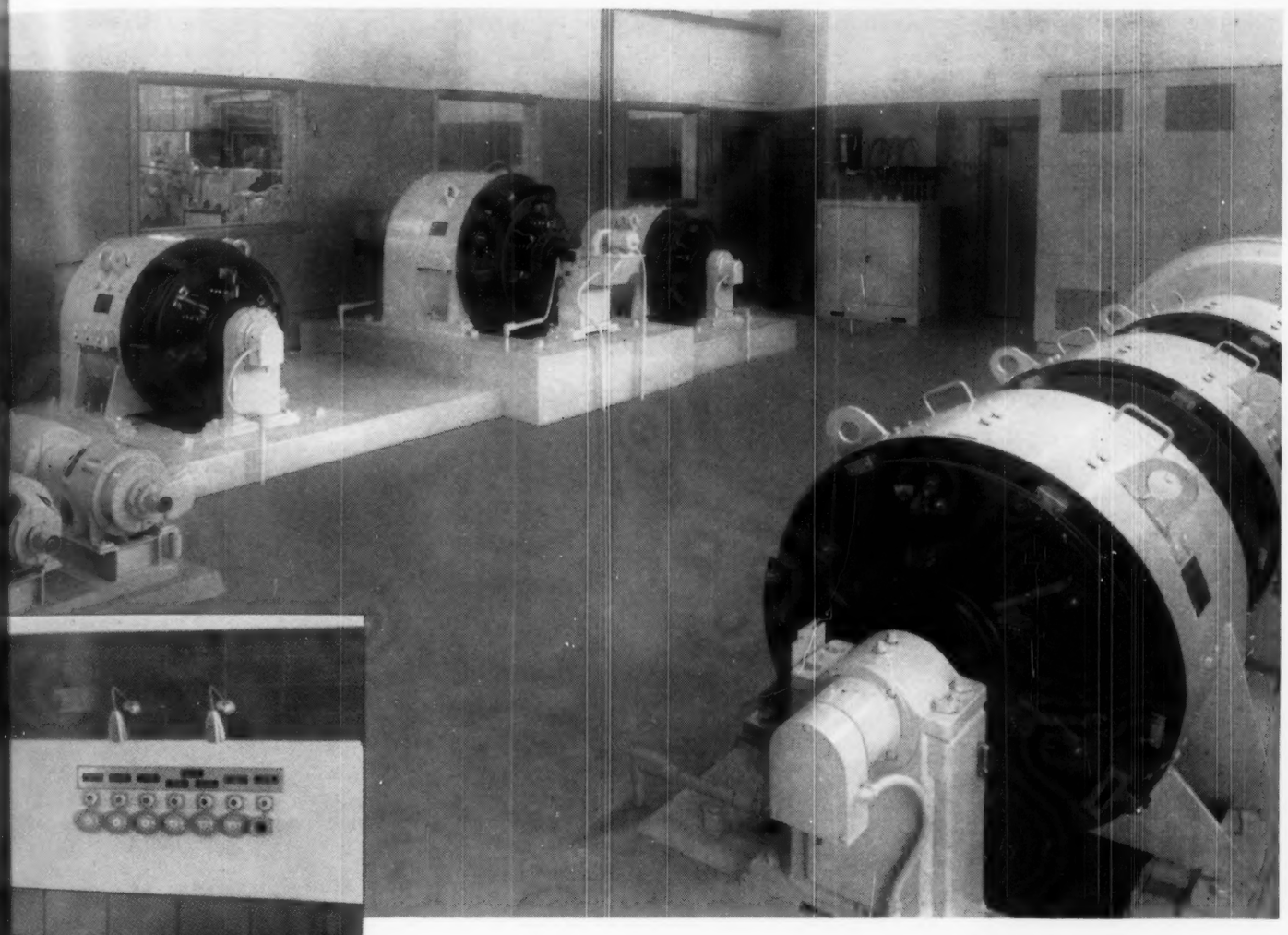
of new Somers Brass Sendzimir Mill

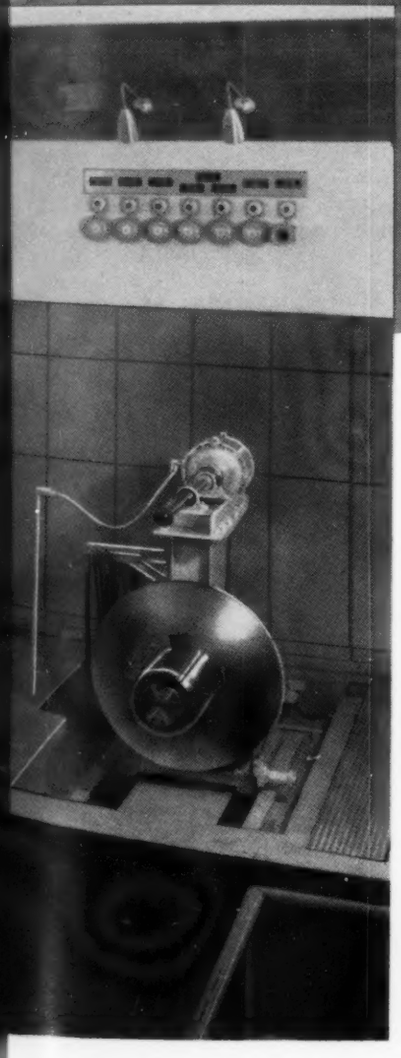
Match precision-engineered Elliott drives to the highly exacting standards of today's modernized rolling mills and you have a winning combination . . . just what you need to keep pace with accelerated tonnage requirements and for quality control.

A typical example of Elliott's contribution in this field is the new Sendzimir cold strip mill seen below, recently installed by the Somers Brass Company in Waterbury, Connecticut. This mill—one of the largest in the non-ferrous industry—is a precision mill requiring precision equipment. Elliott engineered the complete drive including an ingenious arrangement of control equipment which regulates the speed relationship between main rolls and the reels.

The Elliott equipment shown in the photo at the right, includes a 500-hp, 500/900-rpm, 250-volt d-c motor which drives the work rolls, and two 350-hp, 400/800-rpm motors which drive the winding reels. Adjustable voltage power for these motors is supplied by a 5-unit, 725-kw Elliott motor-generator set driven by a 1000-hp, 2300-volt synchronous motor. All main drive machines are built with enclosures for updraft forced ventilation.

ELLIOTT DRIVE





Completely Engineered. The Elliott Industry Engineering Department engineers complete mill drives and coordinates all equipment. Elliott furnishes the complete installation . . . including the rotating electrical equipment, control, switchgear, ventilating equipment, and installation drawings. Call your nearby Elliott District Office for details or write Elliott Company, Ridgway Plant, Ridgway, Pa. Ask for Bulletin Q-23A "Elliott Equipment for the Steel Industry."

ELLIOTT Company

R7-33

"A challenge to all of us". . .

a statement by ***Robert B. Anderson,*** *Secretary of the Treasury:*

"The ownership by 40 million citizens of over 41 billion dollars in Series E and H Savings Bonds is a striking testimonial of confidence in America's bright future. It means security and opportunity for millions of families —a way to provide for children's education, the building of new homes, or more comfortable retirement.

"America benefits, too, from such widespread savings bonds ownership. This partnership of individual citizens in their government's fiscal operations means better management of the public debt—greater stability for our money—brighter prospects for the years ahead.

"Our country *needs* more savings—in all forms, including U.S. Savings Bonds—to help finance our growing economy; to pay for the plants and tools that mean more and better jobs for our ever-increasing population.

"Meeting this need is a challenge to all of us. Americans everywhere should be encouraged to regularly put aside part of their earnings for future needs. And certainly part of that saving belongs in the now better-than-ever U.S. Savings Bonds."

The United States Government does not pay for this advertising. The Treasury Department thanks, for their patriotic donation, the Advertising Council and

IRON AND STEEL ENGINEER

(*Continued from page 251*)

LIFTING MAGNET

△ A 61 in. diam lifting magnet of all-cast-steel construction is announced by The Ohio Electric Mfg. Co.

While designed for use in the scrap industry, the magnet is ideal for any type of operation in which turnings, borings, small thin gage punchings or other scrap of a similar nature must be handled.

Among the advantages claimed are: lower maintenance because of one-piece construction in which

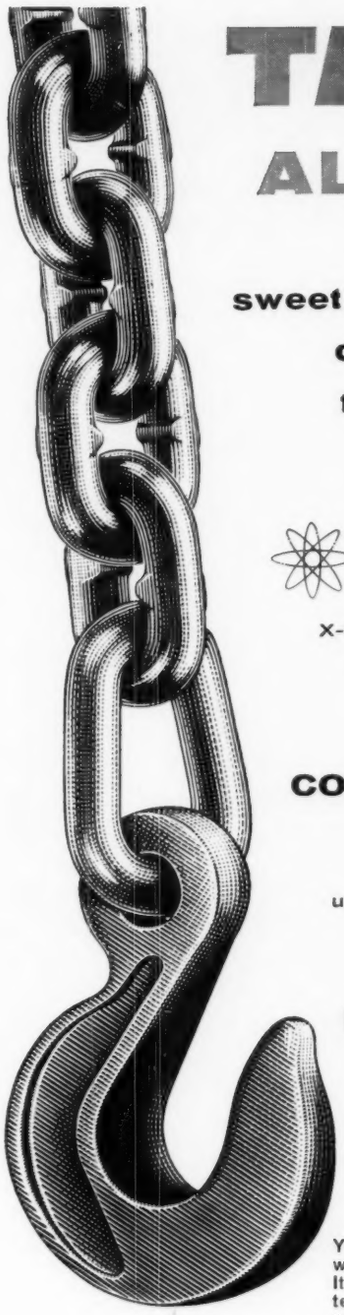
the outer pole shoe, inner pole shoe and top case are all embodied in a single steel casting; and an extremely light weight of only 6750 lb, which is slightly less than standard 55 in. diam bolted magnet types.

The magnet is wound with strip aluminum and has an operating current of 56 amperes. It is filled with a non-remelting type of compound for long trouble-free service. The magnet can be supplied for all standard and special voltages for use with or without Ohio magnet controllers.

OFFSET PRINTER

△ A new development in industrial offset printing is the Matthews No. 248 offset printer, designed to provide continuous, lineal printing on steel, aluminum or plastic pipe, bars, tubing or other like products.

USE THE ENGINEERING MART



Pat. No. 2,646,306

TM Triple-Safe ALLOY CHAIN

sweet music for safety-minded, cost-conscious men throughout industry

GAMMA RAY QUALITY CONTROL!

X-Ray type testing of master, joiner and end links assures safe, trouble-free welds.

CONTROLLED ATMOSPHERE HEAT-TREATING

on all popular sizes provides uniformity throughout the sling assembly.

EXCLUSIVE PATENTED TAYCO HOOKS!

I-Beam type design plus alloy steel construction mean extra safety!

REGISTERED!

You get a certificate of test with every TM Alloy Chain. It bears the chain's guarantee . . . proof test . . . serial number for easy identification.

CERTIFICATE OF TEST

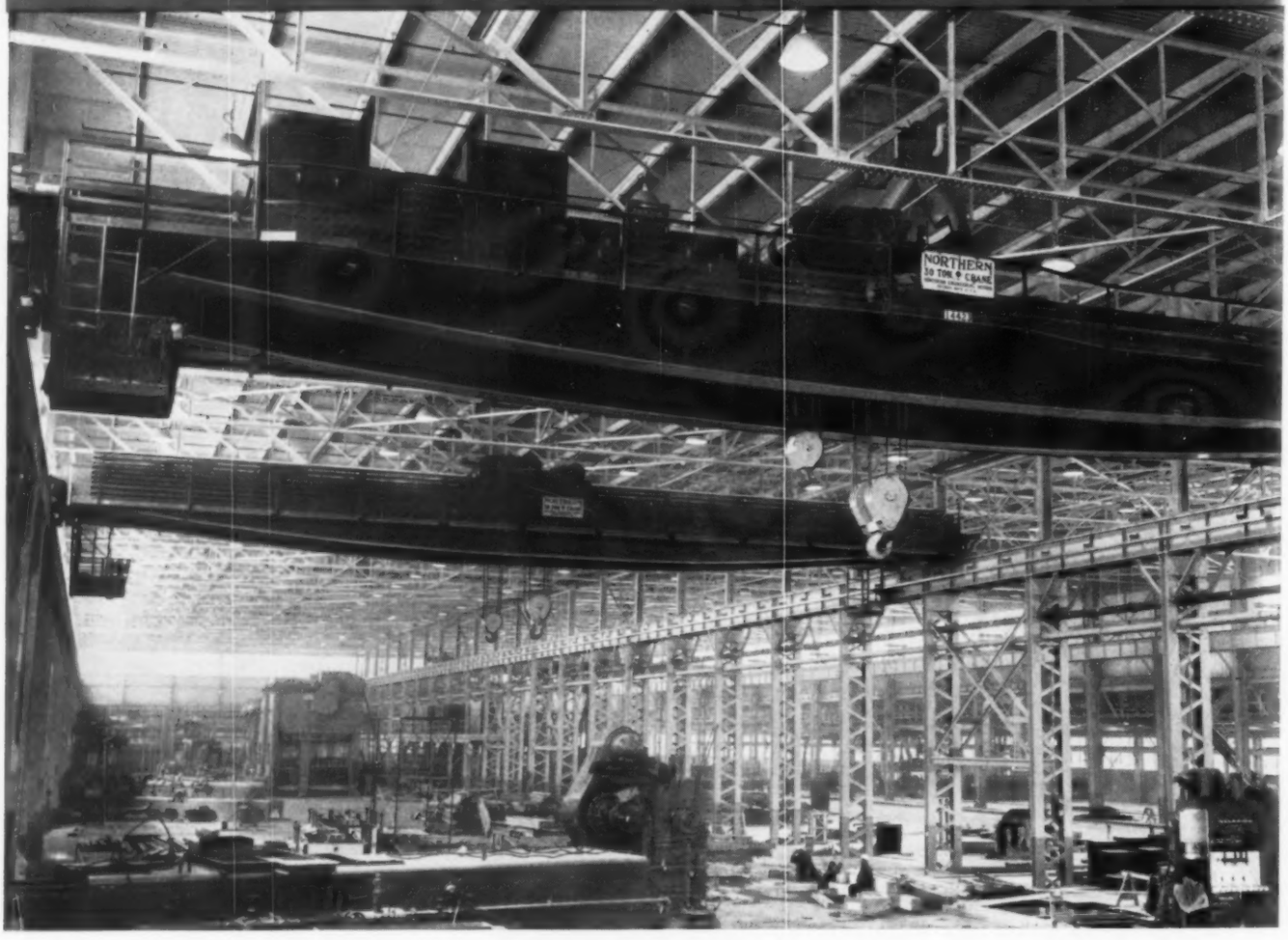
You can boost your safety records up and pull your chain costs down with TM *Triple-Safe* Alloy Chain. Gamma Ray Quality Control, Controlled Atmosphere Heat-Treating and patented Tayco Hooks make it *triple-safe.* And Taylor's special analysis Alloy Steel makes it stronger . . . more resistant to shock, work-hardness and grain-growth! Lasts many times longer! Get *all* the facts—contact your Distributor or write for Bulletin 13 right away.

Chain is our specialty, not our sideline!

TAYLOR MADE A GREAT NAME IN Chain SINCE 1873

Contact your nearest Distributor or write
S. G. TAYLOR CHAIN CO., INC.
Plants: Box 509, Hammond, Indiana
3505 Smallman St., Pittsburgh 1, Pa.

Look Overhead··· see "NORTHERN"



these notable twins assure dependability

LOCATION — *Press bay of a large, new plant manufacturing rear axle parts and components for automobiles and trucks.*

SPAN — *96 feet 10 inches, centers of runways.*

CAPACITY — *30-tons on Main Hooks, 10-tons on auxiliary hooks.*

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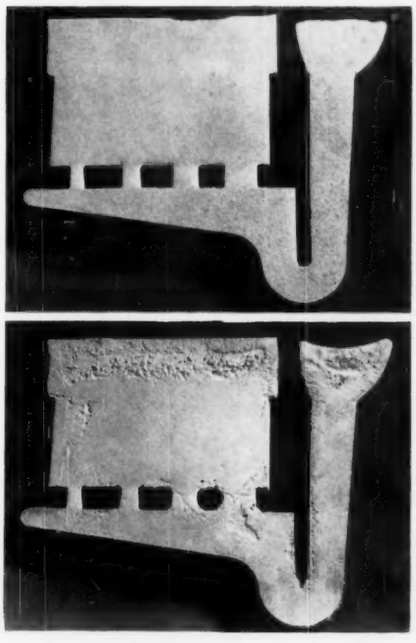
CASTING MATERIAL

△ H-W Forsterite Grains, a new highly-refractory magnesium silicate for shell molding steel castings, has been introduced by Harbison-Walker Refractories Co.—following extensive testing in research and practice—in co-operation with the Steel Founders Society of America.

The material's mineral composition, desirable physical and thermal properties and optimum grain sizing all contribute to its superior per-

At top is a low-carbon casting from H-W Forsterite Grains in shell mold with 5 per cent resin. Below is a low-carbon steel casting from silica sand in shell mold with 5 per cent resin.



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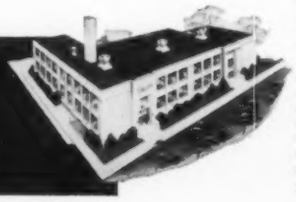

formance in resin-bonded shell molding.

As a result of the optimum chilling effect of Forsterite Grains sufficient strength develops in the skin of the steel casting to resist outside gas pressure as well as inside ferrostatic pressure. This assures a smooth casting surface.

The grains are supplied in controlled sizings. The material also is furnished in 100 and 200-mesh flour for the ultimate in surface smoothness, particularly of castings with heavy sections.

PRECIPITATOR

△ An electrostatic precipitator capable of cleaning 238,000 cfm of gas with an efficiency of 99.5 per cent has been installed at the new plant facilities constructed by Kaiser Engineers at Jones and Laughlin Steel Corp.'s Aliquippa works.

This Cottrell electrostatic precipitator, supplied by Research-Cottrell, Inc., is the first commercial application of an electrostatic precipitator to clean exhaust gases from an oxygen converter.

The advantages of oxygen conversion, such as an installation cost of about half that of an open hearth of equivalent capacity, and use of scrap and molten pig iron to produce steel with lower nitrogen content, have been offset by pessimistic statements concerning the gas cleaning problem, involved in the process.

(*Please turn to page 260*)

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Equipment News

(*Continued from page 258*)

The dust control problem, which confronted European users of the process without satisfactory solution, arises from the composition of the gases evolved from the process. Entrained dust consists mainly of iron oxides, in infinitesimal particles. Studies in Austria indicated a particle size of from 1 to 0.5 microns for 65 per cent of the dust, greater than 1 micron for 15 per cent, with the remaining 20 per cent being smaller than 0.5 microns in size. Actually, American experts have estimated that for each ton of pig iron, about 34 lb of dust is discharged with 90 per cent being minus 1 micron in size.

The precipitator at Jones & Laughlin will be of the horizontal flow plate type. It will have two units, each with three 9-ft sections. Gases generated at the converter will be burned with excess air and then cooled with water sprays to between 350 to 550 F before entering the precipitator. Some of this cooling will take place by radiation during the passage from spark box to precipitator.

Actually, the evolution of waste gases lasts for about 22 minutes. Pouring and recharging of the converter then takes about 18 minutes to give a total time elapsed of 40 minutes per complete cycle, during which 62 tons of metal will be treated. The gases evolved will consist of 12 per cent CO_2, 12 per cent O_2, 67 per cent H_2, and 9 per cent H_2O minimum after cooling. The suspended matter is oxygen converter dust and fume with a concentration of approximately 11 grains per standard cu ft at the precipitator inlet. This gas will be cleaned with an efficiency of 99.5 per cent.

When operating at efficiencies in excess of 99 per cent, as these units will, it is essential to maintain substantially clean collecting plates. This is accomplished in the units by continually operated and automatically controlled magnetic impulse rappers. These units are designed so that the cycle and intensity of electrode rapping can be varied to suit operating conditions. Discharge electrodes are kept clean by high tension vibrators located on top of the insulator compartments.

Research-Cottrell precipitators slated for installation in Kaiser Steel Corp's Fontana Plant are similar to the Aliquippa unit in construction and design, with varying capacities and efficiencies. One unit will clean 405,000 cfm of gas at from 530 to 590 F with 99.7 per cent efficiency. The other will clean 202,500 cfm in the same temperature range with an efficiency of 99.8 per cent. These will be completed early in 1958.

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It teaches you the seven danger signals by which early cancer often reveals itself, and emphasizes your need for an annual health checkup as your best insurance against cancer.

"The Other City" is available, without charge, for showing at your church, your club, your community center, plant or office.

To arrange to see this and other life-saving films, made possible by your contributions, call the Unit of the American Cancer Society in your community or write to "Cancer" in care of your local post office.

AMERICAN CANCER SOCIETY

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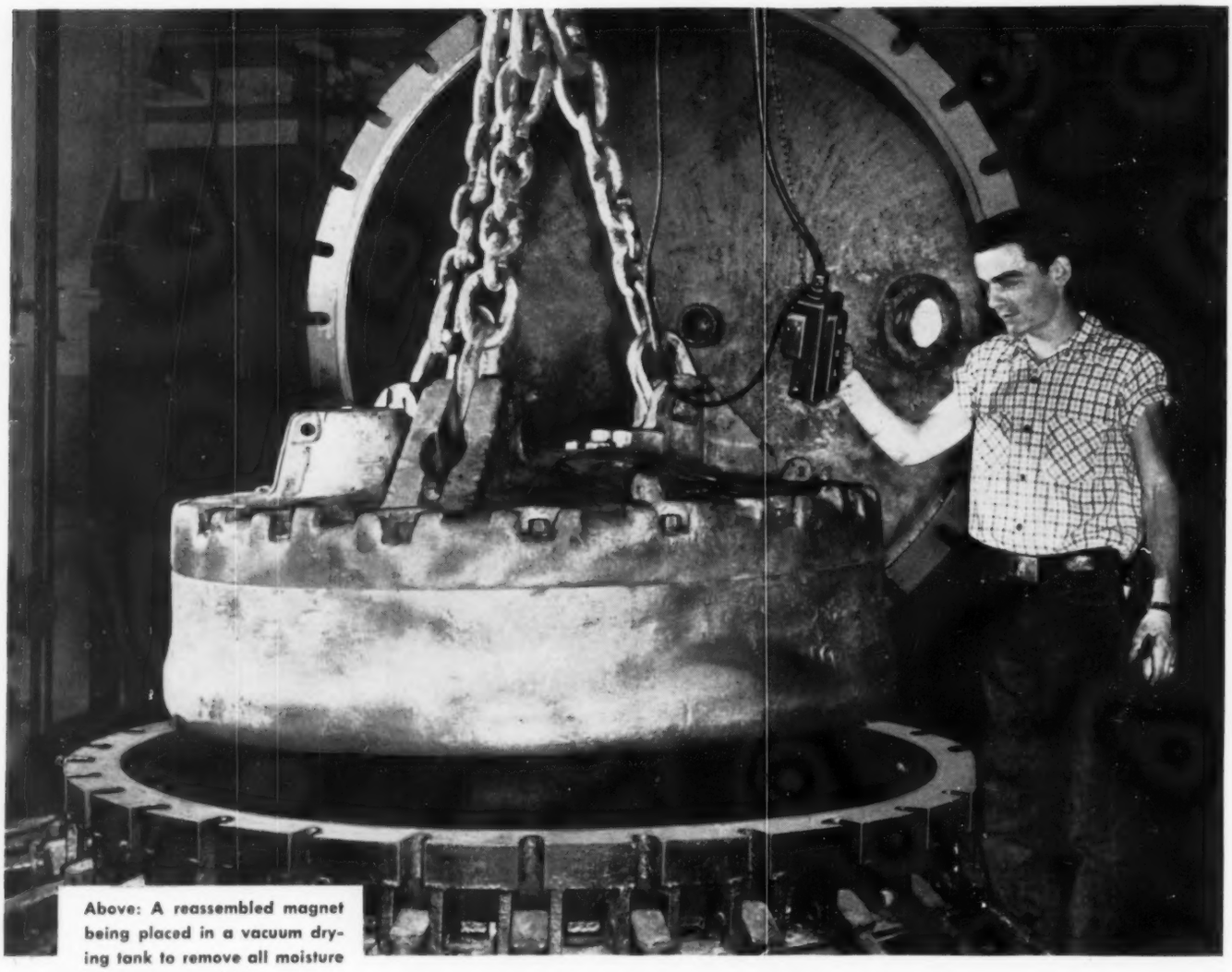

Above: A reassembled magnet being placed in a vacuum drying tank to remove all moisture before compounding.

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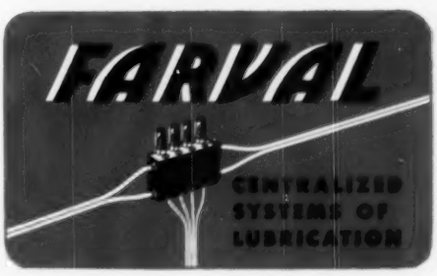

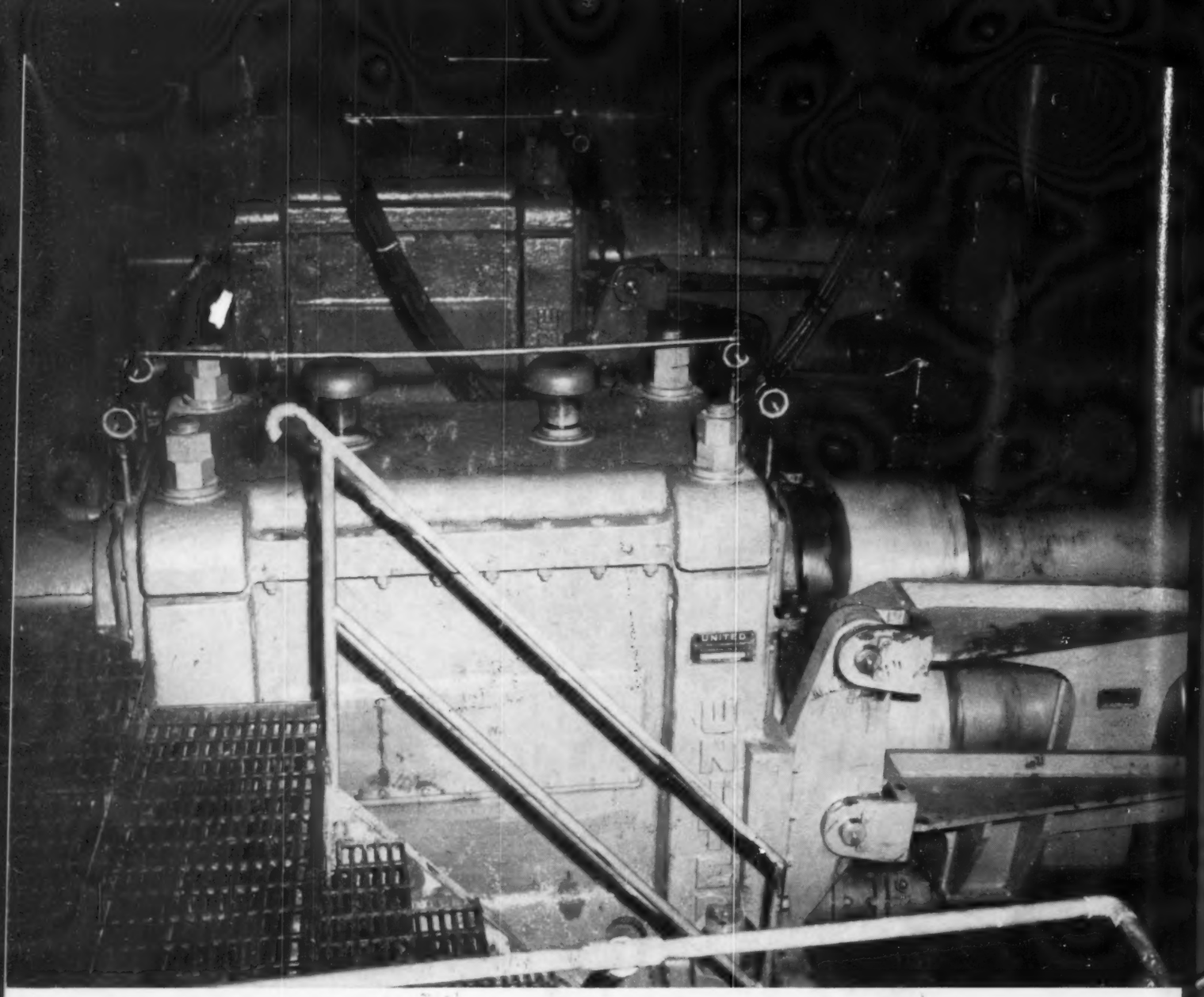

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